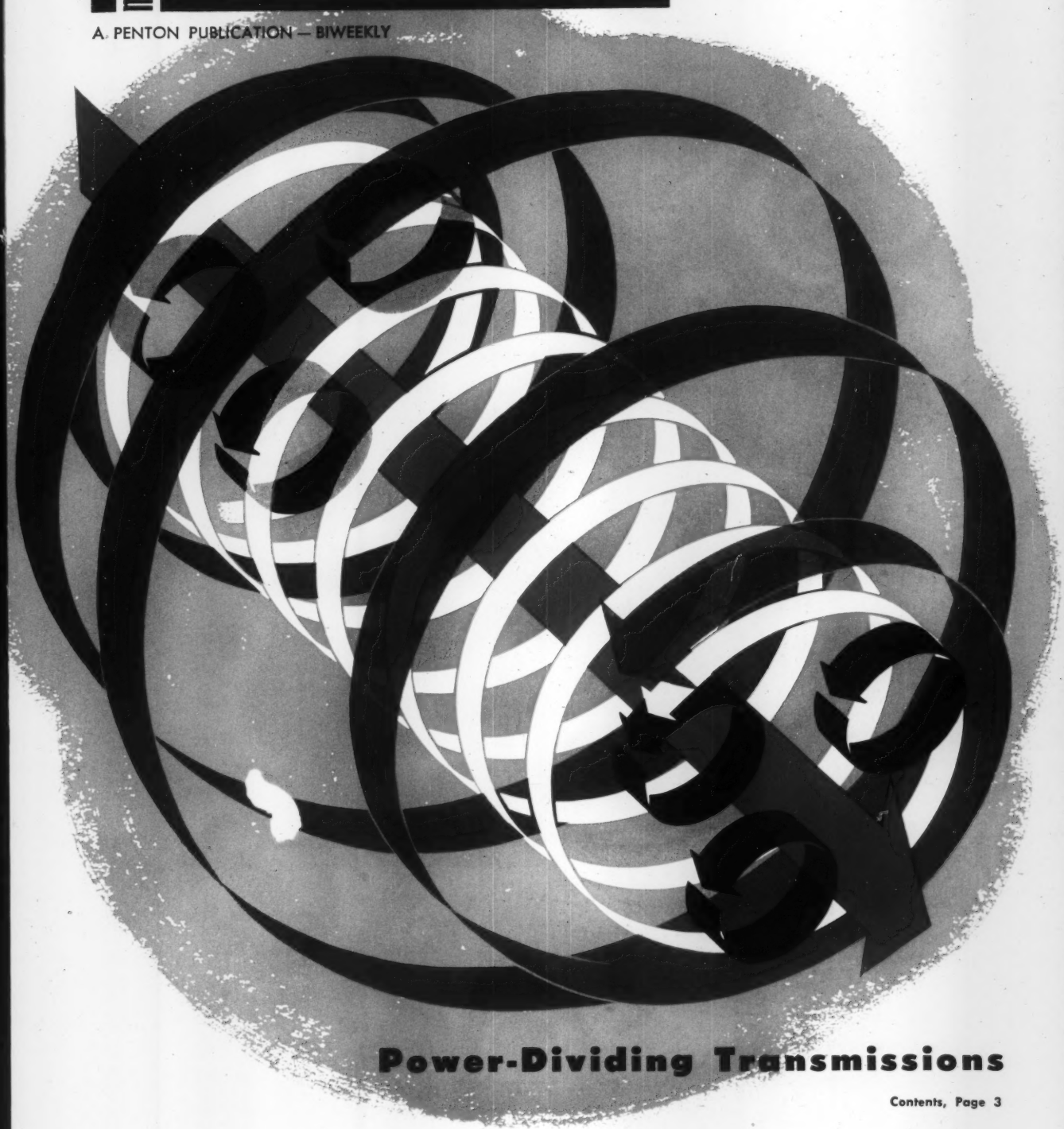
JULY 25, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



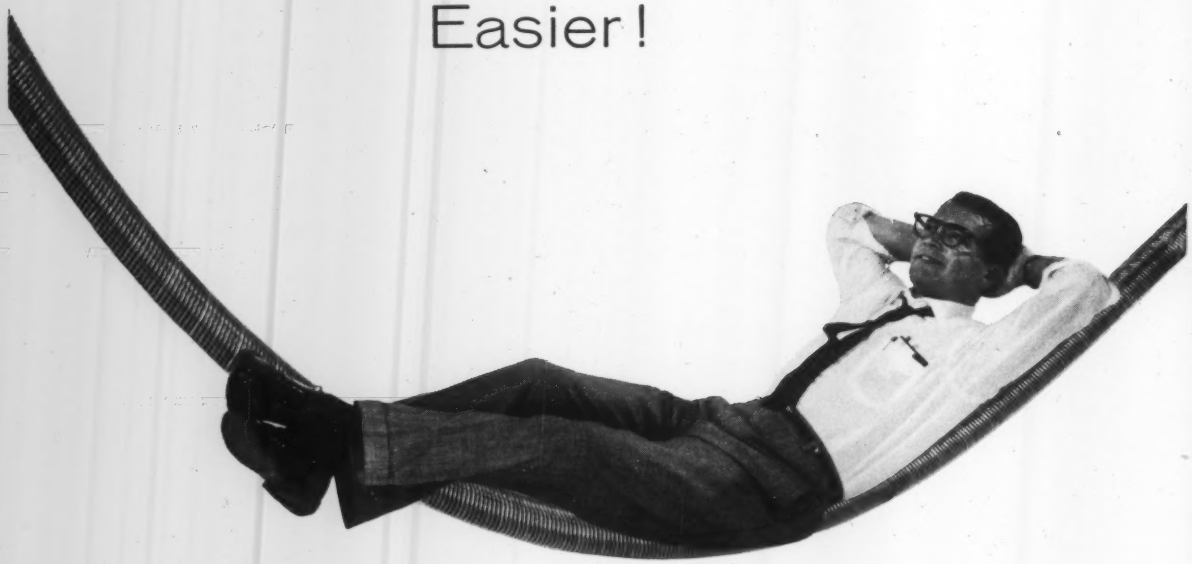
Power-Dividing Transmissions

Contents, Page 3

FARNSWORTH

S.S.White

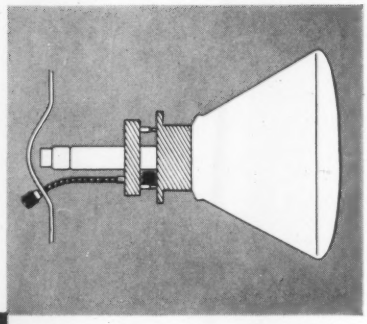
Flexible Shafts Make Operations Easier!



The manufacturer of this hue control for a color TV set uses a standard S.S. WHITE FLEXIBLE SHAFT to cope with a 90° turn. The shaft needs no alignment . . . can be quickly and easily installed. Costs are lower . . . manufacturing is simpler . . . assembly operations are easier, faster.

You can often reduce a complex system of gearing, universals and other parts to ONE FLEXIBLE SHAFT! Flexible shafts also make better designs possible . . . allowing new freedom in locating connected members to save space and facilitate operation and servicing.

For many years, these versatile shafts have been making industrial operations easier. They are tough and rugged . . . yet have the sensitivity you need for delicate adjustments. Design engineers and manufacturers discover new uses for S.S. WHITE FLEXIBLE SHAFTS every day. Can your product be improved by a simple . . . better . . . less costly way of transmitting power or remote control? Our engineers will be glad to work out a flexible shaft application with you. Just write to



S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts. Write for Bulletin 5601.

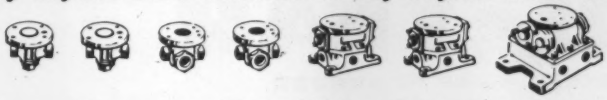
S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Circle 401 on page 19

Ross Skyline

Silvermodel JIC Spool Solenoid

Any Skyline Head Attaches to Any Skyline Valve Body



Interchangeable! 25 Million Cycles in Tests!

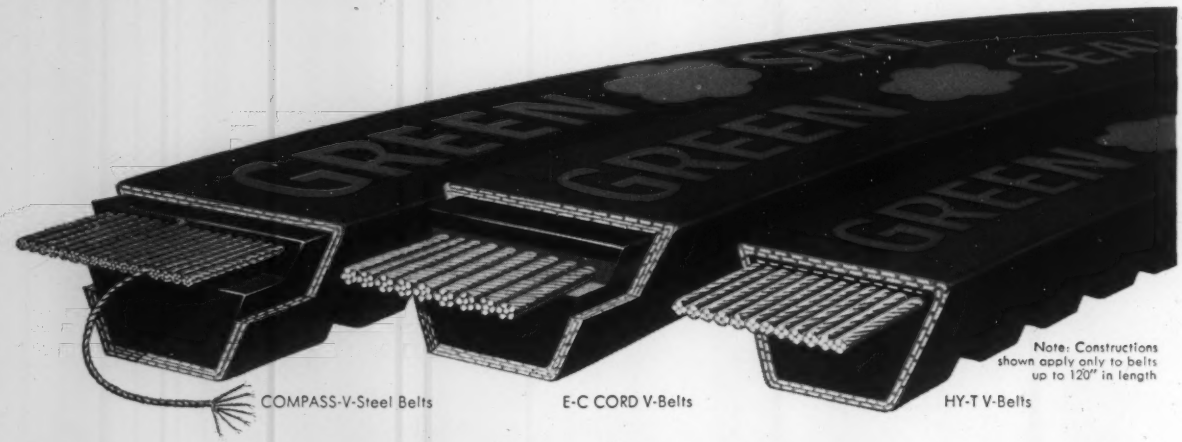
Now the JIC spool solenoid valves join the Ross Skyline. Now six actuating heads and seven in-line and base mounted bodies—all completely interchangeable—give you any valve you want in this series designed especially to last millions more cycles than ordinary valves. But, these quality valves come to you at *sensible* prices! For instance, the ⅜" Silvermodel base mounted, 4-way is only $62.50 complete, and complies with all JIC requirements. Write for bulletin 315.

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

Circle 404 on page 19

Now—V-Belts with the Green Seal solve the major multiple drive problem



COMPASS-V-Steel Belts E-C CORD V-Belts HY-T V-Belts

Note: Constructions shown apply only to belts up to 120" in length

The Green Seal stands for true dimensional stability in V-belts. And with Green Seal dimensionally stable belts you can be sure that matched sets are truly matched and will stay matched—that mismatching (the biggest problem in belting multiple drives successfully) is a thing of the past.

The key to dimensional stability lies in the tension members of the belt. For many years, steel cables as developed by Goodyear were the only length stable load carriers, but now they have been joined by synthetic cords, thanks to the amazing Triple-Tempered 3-T process.

The 3-T process is an exclusive method of tempering the cord with Tension, Temperature and Time for maximum strength and minimum change in dimensions. This assures no change in length during storage plus greatly increased shock- and stretch-resistance on the drive.

The end result is smoother, longer-running teams of belts that give you maximum, trouble-free, horsepower hours at minimum cost. What better reason for specifying V-belts with the Green Seal?

DIMENSIONALLY STABLE V-BELTS with the GREEN SEAL by GOODYEAR

THE GREATEST NAME IN RUBBER

The Goodyear Tire & Rubber Company, Industrial Products Division, Dept. 794, Akron 16, Ohio

Please send me more information about how V-Belts with the Green Seal solve the major problem in belting multiple V-belt drives.

Name_____

Company_____

Street Address_____

City_____ **Zone**_____ **State**_____

Compass, E-C Cord, Hy-T, Green Seal—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

Circle 405 on page 19

July 25, 1957 Volume 29—No. 15

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

Engineering News Roundup . . . 5

Long-life dry battery — electrochemical power source — lightweight gas turbine — cutting costs of screw-machine products — elevator truck body — largest solar furnace — atomic gas mask — new model Jeep trucks.

A Time for Appraisal 71

Editorial — COLIN CARMICHAEL

Scanning the Field for Ideas . . 78

Angular gear-mounting arrangement — pressed-in locking strip for panel seal assembly — matched bifilar resistors in multiple-turn potentiometer construction.

Design in Action 94

Spring-mounted steering-axle design — multiple-function buzzer signal system — automatic hydraulic control system.

Tips and Techniques

Correcting sepia prints, 77; opposite-hand views, 77; eraser holster, 82; protecting layouts, 82; constructing an ellipse, 93; drafting machine aid, 93; simplified slide rule technique, 104; plotting ellipses, 104; lettering guide, 104.

Index (classified by subject) 17

Reader Service Cards 19

Meetings and Expositions 31

Helpful Literature 118

New Parts and Materials 128

Engineering Dept. Equipment 167

The Engineer's Library 171

Noteworthy Patents 176

Advertising Index 183

Business Staff 183

EDITORIAL OFFICES

Penton Building, Cleveland 13, O.

Branch offices: New York, Detroit, Chicago, Pittsburgh, Washington and London

The Engineering Shortage 72

G. WILLIAM KING — A realistic analysis of company engineering-manpower problems and some practical ideas on their solution.

Breach of Employment Contracts 80

ALBERT WOODRUFF GRAY — A review of court decisions on recovery of damages for nonperformance of contract obligations.

Power-Dividing Transmissions 83

D. L. BEDINGFIELD — Fundamental design details, power-flow principles and performance characteristics of transmissions with two and three power paths for control of output speed and torque.

Servo Systems 89

J. M. NIGHTINGALE — *Logarithmic Response Curves* — A convenient method for choosing suitable parameters for networks put in cascade with the forward-path elements to improve performance.

Mechanics of Vehicles—5 98

JAROSLAV J. TABOREK — *Motion-Resisting Forces* — An examination of the characteristics and magnitudes of forces that oppose vehicle motion.

The Engineer as an Executive 103

EDWIN C. NEVIS — *The Personal Side of Engineering* — Basic considerations in the transition from engineer to manager.

Helical Compression Springs 105

JOHN H. KEYES — *Data Sheet* — Nomogram for rapid preliminary design of springs to meet specific size and load requirements.

High-Temperature Alloys 108

N. E. PROMISEL — *Design Abstract*

Gear Drive Design 110

EARLE BUCKINGHAM — *Design Abstract*

Electronic Component Design 114

W. I. BULL — *Design Abstract*

Editor: COLIN CARMICHAEL
Associate Managing Editors: BENJAMIN L. HUMMEL, ROBERT L. STEDFELD
Associate Editors: LEO F. SPECTOR, ROBERT C. RODGERS, WILLIAM S. MILLER, SPENCER R. GRIFFITH
Assistant Editors: JOHN B. HOLT, FRANK M. BUTRICK, FRANCIS A. HUSÁRIK, CLARE E. WISE, JANE H. SMITH, MARIAN L. VLASAK
Art Editor: FRANK H. BURGESS
Contributing Editor: ROGER W. BOLZ

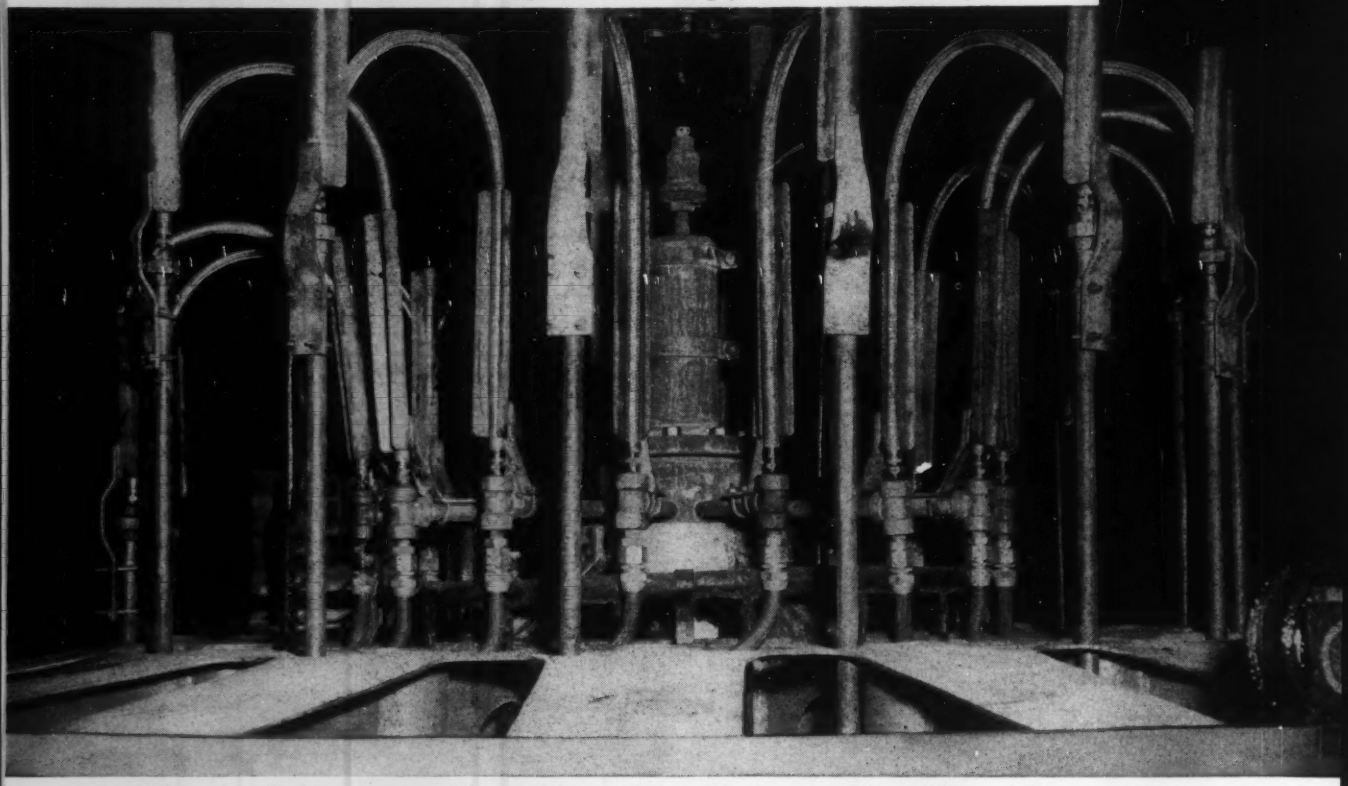
MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U.S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U.S. government installations performing design engineering are also eligible.

Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

Where you convey steam

and have problems of vibration, misalignment, moving parts, or cramped space.



LIVE STEAM flows through this American stainless steel hose at 230 pounds per square inch at 390°F. Hose flexes over 100 times an hour.

You get absolutely "tight" conveyance—under high or low temperatures and pressure—with American Flexible Metal Hose!

Live steam "on the loose" can be costly . . . and dangerous. That's the problem facing the Diamond Match Company. The job: conveying live steam around a 180° bend . . . in a conveyor which must undergo continuous flexing.

Many lines were tried—and failed. American stainless steel hose was finally suggested, and is now doing the job! This is not unusual. American flexible metal hose has a long record of peak performance in the field.

It absorbs vibration and prevents its transmission to surrounding structures . . . absorbs expansion and contraction in lines due to temperature changes . . . facilitates installation, especially in cramped spaces . . . and solves the problems of misalignment.

Available in wide range of diameters in tough bronze, steel, super nickel, brass, stainless steel and other metals, American flexible metal hose delivers the very highest service hours per dollar. American furnishes flexible metal connectors to your specifications . . . ready for immediate installation.

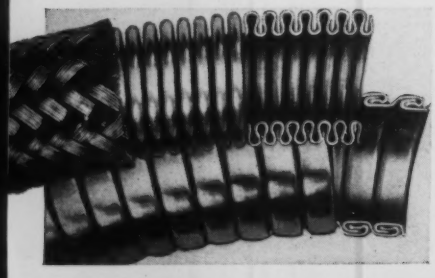
Consult your nearby American Metal Hose representative for engineering help when planning your next job. No obligation. See American Brass Company or Anaconda in your phone book—or write: American Metal Hose Division, American Brass Company, Waterbury 20, Conn.

WHEREVER CONNECTORS MUST MOVE

56178 Rev.

AMERICAN FLEXIBLE METAL HOSE AND TUBING

AN **ANACONDA®** PRODUCT



BASIC TYPES

Seamless corrugated and Strip-wound. Both types available in a wide range of sizes and styles in any workable metal. Furnished with or without end fittings attached.

Circle 406 on page 19

THE AMERICAN BRASS COMPANY
American Metal Hose Division, Waterbury 20, Conn.

Please send me a free copy of your new flexible metal hose and tubing catalog, G-560.

NAME & TITLE.....

ADDRESS.....

COMPANY.....

CITY, ZONE, STATE.....

Engineering News Roundup

Dry Battery Takes Hard Knocks, Long Storage, Many Recharges

Cell Operates in Deep Cold, Won't Leak Electrolyte

WASHINGTON, D. C. — Indefinitely long shelf life and unusually high resistance to shock and vibration are outstanding properties of a new dry battery developed at the Naval Ordnance Laboratory.

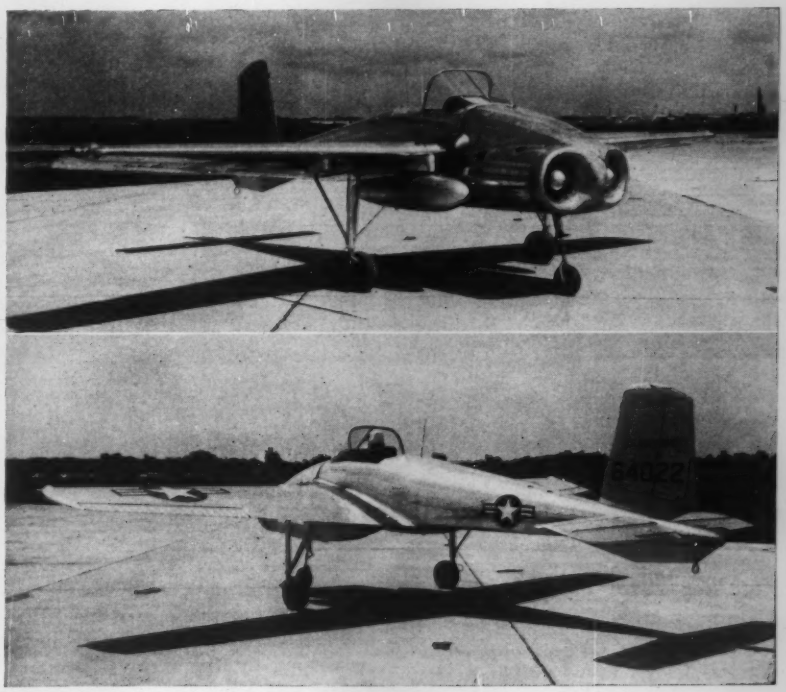
Good temperature resistance and absence of electrolyte leakage are other noteworthy properties of the new battery.

The battery has a chemical action which is completely reversible and does not gas when charging.

A single cell of the new battery delivers 0.9-v compared with 1.5-v output of the commonplace type of dry cell. The cell has a capacity of 1.5 ampere-hours.

The complete cell is enclosed in a metallic case about the size of a man's wrist watch. This, in turn, is sealed with a special resin and encased in plastic.

Designated XA-108, the battery has been released for use to the general public under Federally owned patent number 2697736.



DIVERTED JET THRUST enables helicopter performance of the experimental X-14 by Bell Aircraft Corp. Powered by two Armstrong-Siddely jet engines, the X-14 takes off and lands vertically without departing from the conventional horizontal attitude. This eliminates the need for a runway and elaborate ground handling equipment. Diverters or vanes behind the engine direct jet thrust downward during vertical travel and hovering flight. For forward flight, the pilot redirects thrust rearward. While hovering directional controls are compressed air nozzles at wing tips.

Group Advises Practices to Cut Screw-Machine Products Cost

CLEVELAND, O.—To understand the reasons for price variation in its own industry, the National Screw Machine Products Association has conducted eleven regional estimating clinics in key cities across the country. Engineers and management personnel prepared estimates on a single selected screw-machine product. They used hypothetical machine rates and they assumed certain limitations on production equipment to necessitate some secondary operations for the test.

Results of the meetings showed that purchasing agents, designers and estimators can reduce bid variation by following certain broad principles of operation.

For engineers and designers, NSMPA offers the following considerations:

1. Choose the most easily machined material consistent with actual use of the part.

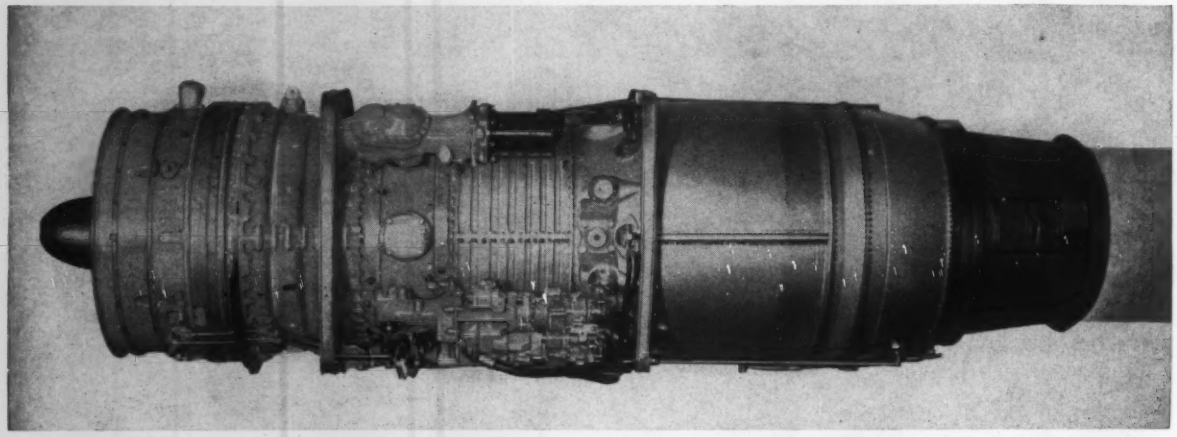
2. Do not make specifications closer than necessary. Extra fine tolerances require additional supervision, expensive tooling, frequent tool readjustment.

3. Specify American National or Unified threads. Special threads require special tools, thread gages, more inspection.

4. Use hole diameters obtainable with standard drills and reamers. Special tools mean greater cost.

5. Don't specify a finish when it is not necessary. If the part is not seen, does not move, does not require a close fit, there is no point in putting it through unnecessary surface-finish operations.

6. Check the design against end use to see if some secondary opera-



COOL AND QUIET, the new TJ38 turbojet was designed expressly for use in commercial airliners by Curtiss-Wright Corp. and Bristol Aeroplane Co. Ltd. Operating temperature is said to be 360 F lower than other turbojets, resulting in increased parts life, less maintenance. Low noise level, achieved by new segmented suppressor, makes operation acceptable for existing airport facilities. Rapid climb-out performance from any airport will further minimize noise patterns relative to both time and distance. Engine is rated at 12,500 lb thrust, weighs 3600 lb. Weight is 17 per cent less than comparable military engines.

tions can be eliminated. For example, burrs might be eliminated by specifying either chamfered or rounded corners on parts, instead of sharp corners.

Eighteen Edsel Models Comprise New Ford Line

BUFFALO, N. Y. — Five station wagons and two convertibles will be among eighteen available body styles in the medium-priced Edsel line to be introduced this fall by Ford Motor Co.

Four series, starting with the lowest priced, will be Ranger, Pacer, Corsair and Citation.

Lowest priced Ranger series will include two and four-door sedans; two and four-door hardtops. Pacer series includes convertible, four-door sedan and two and four-door hardtops. Corsair series will have two and four-door hardtops, while the Citation series includes convertible, two-door and four-door hardtops.

Line of five station wagons will include the Roundup, a two-door, six-passenger model; the Villager, a four-door six or nine-passenger model; and Bermuda, the top station wagon, also a six or nine-passenger car.

Army Mask Traps Gas And Atom Fallout Too

Filter Pouches Supersede Former Hose And Canister

PITTSBURGH, PA.—Radioactive particles as well as a wide variety of war gases are trapped in the filter element of a new protective mask developed by the Army Chemical Corps and Mine Safety Appliances Co.

The new mask is also light in weight and has no bulky outside canister. It offers less resistance to breathing than former masks; gives the wearer increased vision and better speech transmission.

Atomic-age gas mask, designated E-13 by Army Chemical Corps, traps radioactive fallout particles with impregnated glass fiber in cheek pouches. Gone are hose, canister.

Instead of a hose and canister, the new mask has two pouches, one on each side of the facepiece. In these pouches are pads of gas-aerosol filter material composed of finely-ground charcoal, plastic and glass fiber. The pads are formed from strips of the material easily cut and formed to shape. Pads would be changed after each exposure to atom matter.

The entire mask is in one piece. Smooth outside contours lessen the possibility that the wearer might catch the mask on obstacles. A speaking diaphragm built into the mask enables the wearer to talk and use a telephone or radio without special equipment.

Front Cover

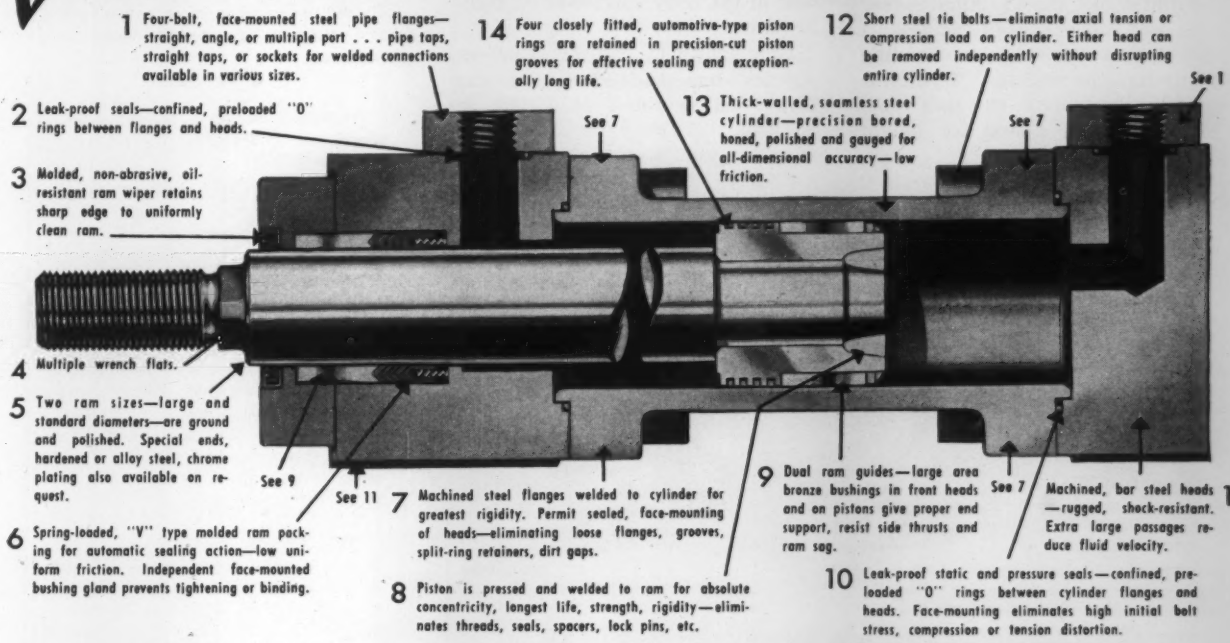
Although usually invisible to the naked eye, power flow in a divided-path transmission comes vividly to life in a colorful pattern of lines and arrows captured by the imaginative brush of George Farnsworth on the front cover. For a more practical picture of this subject, see D. L. Bedingfield's article beginning on page 83.

. . . Fluid Power news

NEW HEAVY DUTY CYLINDERS

NOW AVAILABLE—New Oilgear "Custom-Quality" Line of Heavy-Duty, 3,500 psi Cylinders

✓Check . . . Compare these 20 "Custom-Quality" features:


1 Four-bolt, face-mounted steel pipe flanges—straight, angle, or multiple port . . . pipe taps, straight taps, or sockets for welded connections available in various sizes.
2 Leak-proof seals—confined, preloaded "O" rings between flanges and heads.
3 Molded, non-abrasive, oil-resistant ram wiper retains sharp edge to uniformly clean ram.
4 Multiple wrench flats.
5 Two ram sizes—large and standard diameters—are ground and polished. Special ends, hardened or alloy steel, chrome plating also available on request.
6 Spring-loaded, "V" type molded ram packing for automatic sealing action—low uniform friction. Independent face-mounted bushing gland prevents tightening or binding.
7 Machined steel flanges welded to cylinder for greatest rigidity. Permit sealed, face-mounting of heads—eliminating loose flanges, grooves, split-ring retainers, dirt gaps.
8 Piston is pressed and welded to ram for absolute concentricity, longest life, strength, rigidity—eliminates threads, seals, spacers, lock pins, etc.
9 Dual ram guides—large area bronze bushings in front heads and on pistons give proper end support, resist side thrusts and ram sag.
10 Leak-proof static and pressure seals—confined, preloaded "O" rings between cylinder flanges and heads. Face-mounting eliminates high initial bolt stress, compression or tension distortion.
11 Machined, bar steel heads—rugged, shock-resistant. Extra large passages reduce fluid velocity.
12 Short steel tie bolts—eliminate axial tension or compression load on cylinder. Either head can be removed independently without disrupting entire cylinder.
13 Thick-walled, seamless steel cylinder—precision bored, honed, polished and gauged for all-dimensional accuracy—low friction.
14 Four closely fitted, automotive-type piston rings are retained in precision-cut piston grooves for effective sealing and exceptionally long life.
See 1
See 7
See 7
See 7
See 9
See 11

15 Adjustable hydraulic cushions—dash pots—for front, rear, or both heads. New, exclusive Oilgear floating-sleeve design assures superior performance, longer life, less wear—eliminates check valves.

16 Eight basic sizes—2", 2½", 3¼", 4", 5", 6", 7", 8" . . . length of stroke varies from 36" to 158". Longer stroke available on request.

17 Air vent plugs, double end rams, special ram ends, special packings for use with fire-resistant fluids are also available.

18 Choice of fixed mountings—foot lug, center lug, or flange—can be combined or interchanged, front or rear, to suit any requirement.

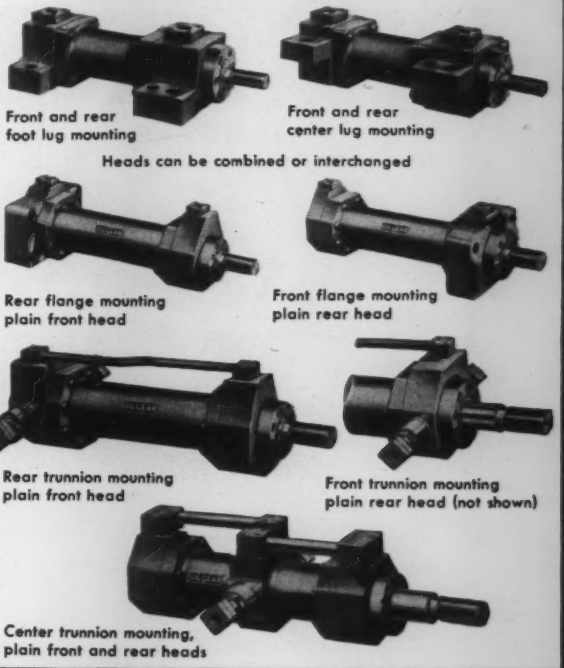
19 Choice of hollow trunnion mountings—rear, center, front—accurately machined, integral with heads. No hoses or slide joints—Oilgear's exclusive steel flange connectors—rugged, leak-proof, rotate smoothly.

20 Designed and built to the highest standard of quality for the most dependable, trouble-free, long life. Machinery builders and users alike, say—"For the lowest cost per year—it's Oilgear!"

Complete user satisfaction is guaranteed by Oilgear's extensive research, testing, over 35 years of design, manufacturing, and application experience in the field of Fluid Power—both oil and fire-resistant fluids.

For further information on these new cylinders, call your Oilgear Application-Engineer. Or write for bulletins 73000 and 73245 directly to . . .

STANDARD MOUNTINGS


Front and rear foot lug mounting
Front and rear center lug mounting
Heads can be combined or interchanged
Rear flange mounting plain front head
Front flange mounting plain rear head
Rear trunnion mounting plain front head
Front trunnion mounting plain rear head (not shown)
Center trunnion mounting, plain front and rear heads

THE OILGEAR COMPANY

Application-Engineered Fluid Power Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Elevator Truck Body Saves Loading Time, Effort

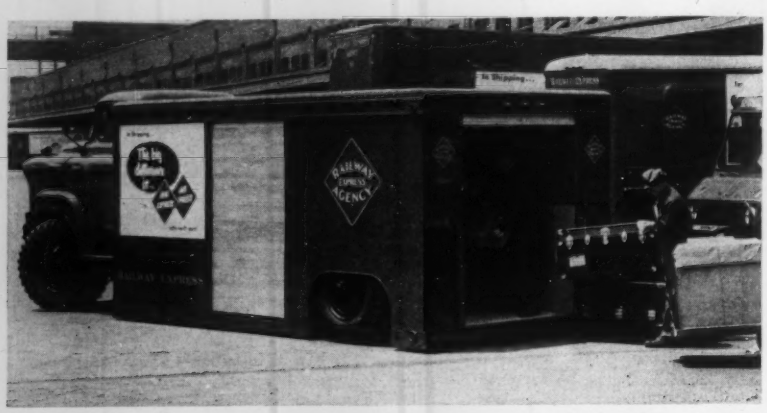
NEW YORK, N.Y. — Hydraulically activated truck body that raises, lowers or tilts for variety of platform heights is announced by Thompson Trailer Corp. Body works like an elevator, moving from ground level to maximum height of 54 in.

Front-wheel drive eliminates rear axle and conventional driveshaft and makes possible low loading position of the vehicle. Hydraulic cylinder attached to each rear wheel provides power for height adjustment.

Mating channels that connect body and chassis act as elevator guides. A third hydraulic cylinder located in this connecting frame operates elevating mechanism similar to that in fork trucks.

Since all three hydraulic cylinders operate independently, the body can be lowered either frontward or backward and to either side. Rear tire can be changed by merely placing a block under rear of the body and lowering body to rest.

Unit shown by Railway Express Agency has 16-ft body, weighs 10,000 lb, is rated at 10,000 lb payload. Variety of body types with capacities to 20,000 lb is available.



Elevator body lowered to street level for easy, safe loading. Further adjustment is possible to conform with any dock angle or height to 54 in.

Front end of body raised to provide gravity pull for roller conveyor in unloading. To load, process can be reversed by lowering front of body.

Topics

The knothole set has a treat in store, thanks to an unusual use of electronics. Construction of a building at 575 Lexington Ave. in New York City will be televised via closed circuit to three 21-inch receivers located in the area. The TV camera, complete with telephoto lens, will be used to show construction details heretofore not visible to even the most eagle-eyed and diligent of sidewalk superintendents.

• • •

Antique in the machine-tool world, an 1889 model turret lathe has been donated to the Smithsonian Institution by Gisholt Machine Co. The machine is one of the first manufactured by Gisholt.

• • •

Leonardo da Vinci, to be launched in 1958, will be the first new transatlantic Italian passenger liner equipped with stabilizers to reduce rolling in rough seas. Design of the ship, a somewhat larger replacement for the *Andrea Doria,* permits conversion to nuclear propulsion.

• • •

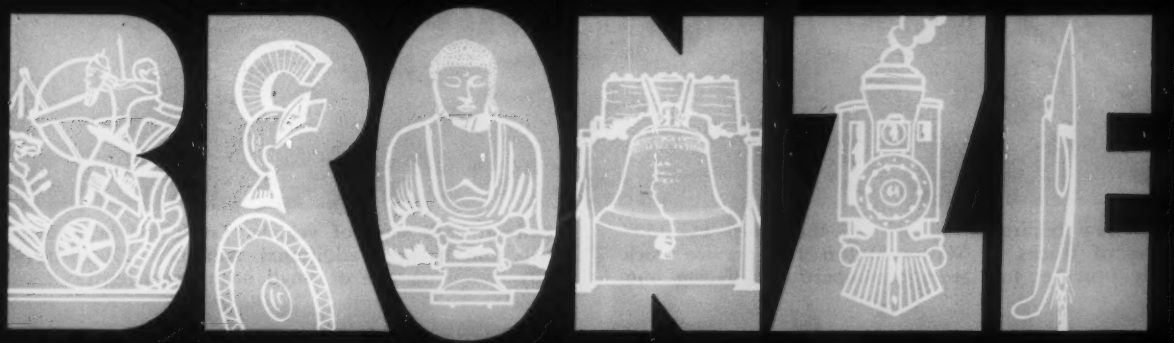
How warm can you get? The answer to this question, important to designers of aircraft that will encounter the "thermal thicket," is indicated by results of recent student-pilot experiments. Between 120 and 235 F, performance was near normal for about 75 per cent of the safe exposure time for a given temperature. During the last quarter of the time, there were symptoms such as dizziness, faintness, mental confusion and nausea, followed by a sharp increase in errors in handling the controls. Figures indicate that under specified conditions a man covered with protective clothing 1 cm thick might remain as long as 90 seconds in air at 900 F without collapse.

• • •

Biggest improvement in windmill operation in 40 years is claimed as the result of a device developed by a Johannesburg, South Africa, inventor. A variable hydraulic gear and automatic clutch arrangement reduces or increases the pumping stroke in proportion to wind velocity. Ordinarily, windmills stall when wind velocity is under 5 mph.

Circle 407 on page 19→

BRONZE



. . . . Through the Ages

Since the dawn of recorded history man has consistently called on bronze for the most arduous of metal-working tasks . . . Today leaders of every industry are asking Bound Brook, the world's leading specialists in sintered bearings, to solve their bearing problems. COMPO oil retaining bronze bearings can be purchased from stock for most applications or specially alloyed and tailored to meet your requirements. Call your Bound Brook man now.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

ESTABLISHED 1883

Two new bodies developed for the "Jeep FC 150" series of trucks by Willys Motors Inc. Service truck body provides tool storage compartments facing outward on both sides of vehicle. Truck bed between is open for hauling additional materials. Dump-truck body completes line of small utility vehicles.

New Model Jeep Trucks Are Larger, More Powerful

New Bodies Also Added To Smaller Truck Series

TOLEDO, O. — Larger cab-over-engine Jeep with gross weight rating of 7000 lb and wheelbase of 103.5 in. has been introduced by Willys Motors Inc. Identified as "Forward Control Jeep FC 170," its payload is 30 per cent greater than the smaller FC 150 series of trucks introduced earlier. Super-Hurricane engine features a new cam design and provides 190 ft lb of torque at 1400 rpm.

Nine forward and three reverse power combinations are possible with standard transmission. Optional four-speed transmission allows twelve forward speeds. Transition from four-wheel to conventional two-wheel drive is made by shifting new single control lever without stopping the vehicle.

Equipped with power take-off, the truck provides source of stationary power available at rear for winches and belt and shaft-driven equipment, and at center for operation of generators, welders and other bed - mounted machinery. Pickup or stake bodies provide 9 ft of cargo length.

Other features include suspended brake and clutch pedals, 1200 sq in. wrap-around windshield, acoustical trim interior panels and level-plane steering wheel. Cab is well insulated against engine heat, sound.

Overall length is 181.5 in.; width, 76.75 in.; and height, 79.5 in.

New "Jeep FC 170" continues overall styling and engineering characteristics of the smaller FC 150 series. Size and engine performance have been increased to provide 3,510 lb of payload capacity in 9-ft cargo bed.

Mercury Lamp For Area Lighting Is High Performer Mounted High

Most Efficient of Type to Start Work at N. Y. Airport

CLEVELAND, O.—Primary outdoor illumination at the new International Airport, New York, will be provided by installations of a high performance mercury lamp three times as effective as conventional luminaires. The new lamp is claimed to be the most efficient mercury type ever designed for general area lighting. Performance is 54 lumens per watt.

Designated Mercury 1500, the new lamp was developed by the General Electric Lamp Div. at Nela Park. It is tubular in shape and operates without the glass jacket usually associated with lamps of this type. Luminaire housing serves as a protective jacket which also absorbs ultra-violet radiation produced by the lamp.

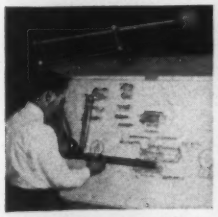
Overall length of the Mercury 1500 is 19 9/16 in. Nominal lighted length is 12 in. It has a single contact terminal at each end fitted into a specially designed ceramic base which is slotted along its length to provide convection cooling for operation at high temperatures.

Operating at 1500 w, the new lamp is rated 81,000 lumens. It will perform effectively at temperatures as low as − 20 F when equipped with the proper ballasts.

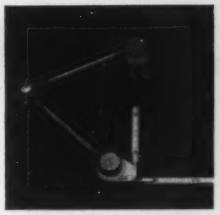
At International Airport, a

"And I Said I'd Never Use a Drafting Machine"

Bruning Track Drafters bring new space-saving efficiency and accuracy to firms that need extra-large drawings. Single-arm and double-arm models offer automatic indexing, double verniers, fast scale changes and up to 84" vertical coverage.



Bruning Counterbalanced Drafters provide unusual speed, accuracy in vertical drafting. Arm lengths available to cover 36" x 60" to 48" x 96" areas.



Bruning Detail Drafters are a smaller, lower priced variation of larger Bruning machines. Ideal for shops, schools, and in the field.

"That Was Before I Tried a Bruning Equipoise Drafter!"

Take a tip from an increasing number of draftsmen who, perhaps like yourself, were reluctant to try any drafting machine or had been disappointed in a conventional type drafter. These men now report: Bruning Equipoise Drafters cut drafting time over conventional equipment up to 40% on most jobs, up to 50% on some structural drawings — beat any other drafting machine they ever tried.

But prove it to yourself! See how fast you'll work with one precision instrument combining T-square, straightedge, triangle, protractor, and scales. Feel how the patented Equipoise mechanism eliminates any drift from gravity, literally makes the drafter "float" into place. Find how easy it is to rotate, turn, and lift this drafter — all with the left hand. At the same time, operate the Touch Control button with your left thumb to set the drafter automatically at any of 24 commonly used 15-degree increment angles. Don't overlook the special scale lock that makes it easy to change the scales, holds the scales rigid.

Your own test will convince you of the superiority of a Bruning Equipoise Drafter. Mail coupon today!

America's Leading Supplier of Engineering and Drafting Equipment.

BRUNING

Offices in 38 cities of the U.S. and Canada.

CHARLES BRUNING COMPANY, INC., Chicago 41, Illinois

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept. 74-K
4700 Montrose Ave., Chicago 41, Illinois

Please send me the free booklet on Bruning Drafting Machines.

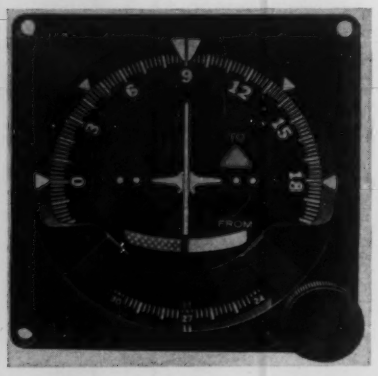
Name_____ **Title**_____

Company_____

Address_____

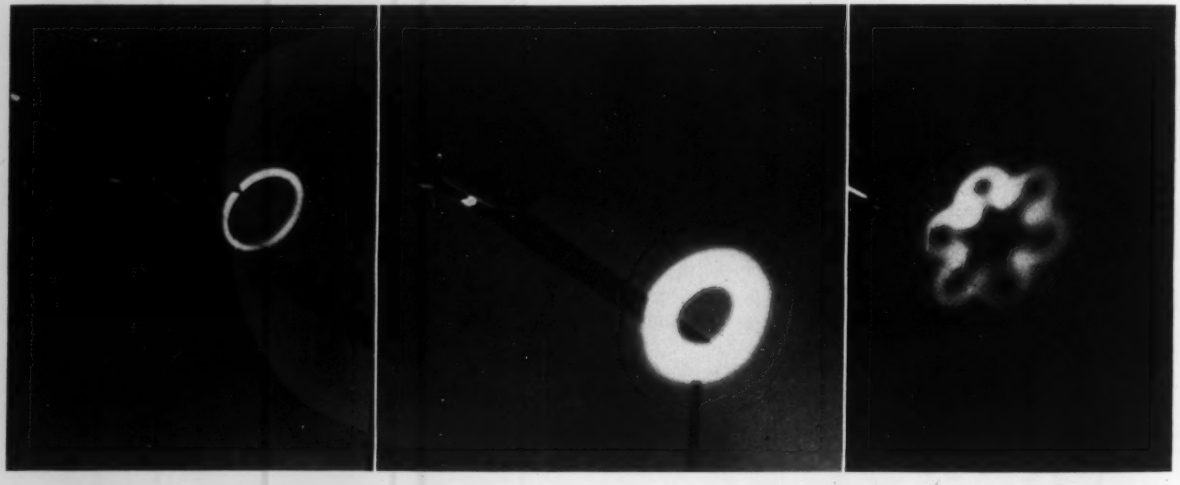
City_____ **County**_____ **State**_____

total of 334 of the new lamps will be mounted in groups of six, eight, ten and twelve on 43 pylons 75 ft high.



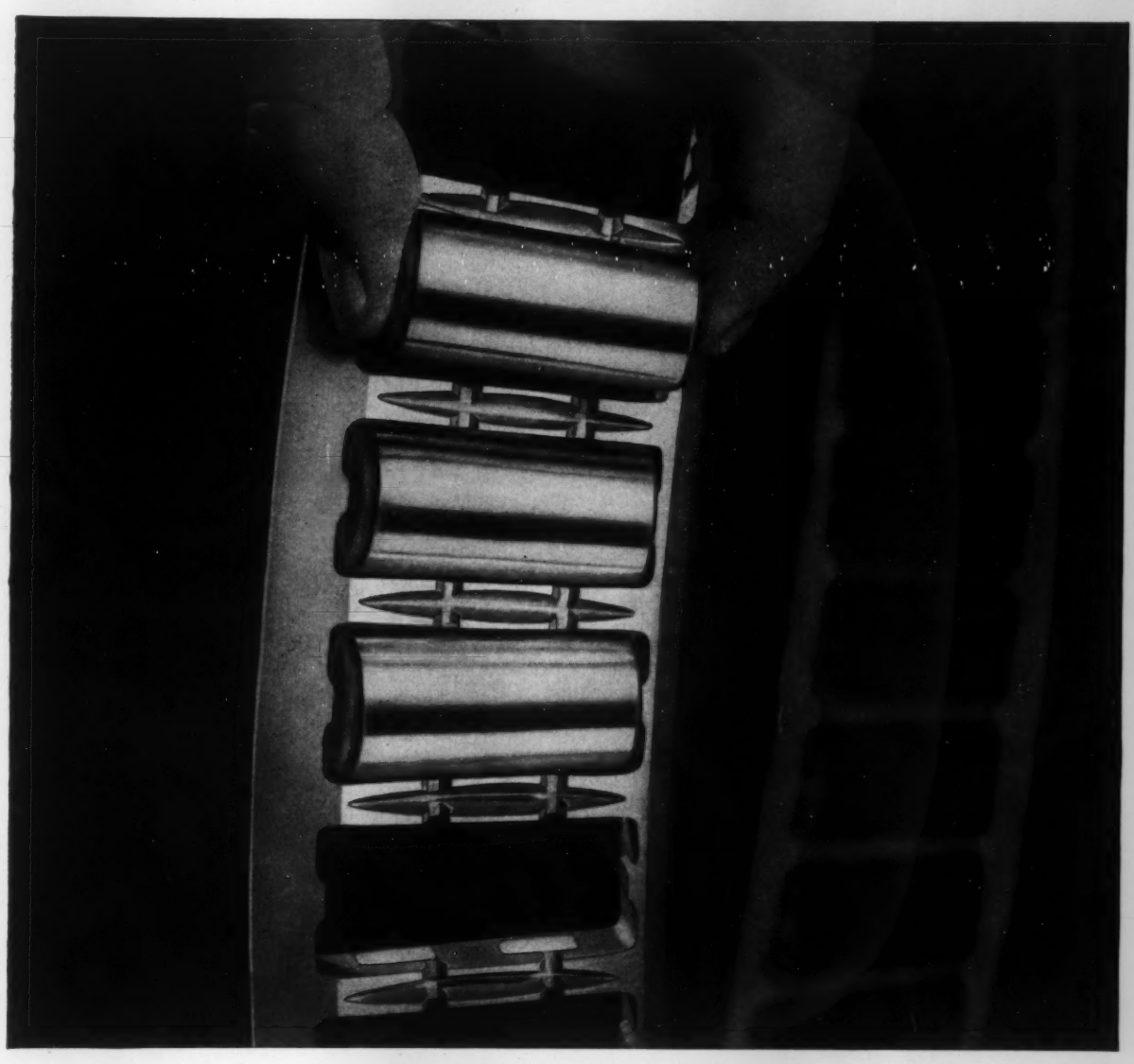
FIVE-IN-ONE DISPLAY of flight data in easier to read presentation is featured in new version of omni indicators developed by Lear Inc. Course selection is made by rotating azimuth card so that selected course coincides with index at top center of instrument face. Heading changes of 100 degrees are thus read directly without necessity of mental arithmetic. Left-Right indication is shown by usual vertical needle. To-From information is clearly presented with arrowheads. Reciprocal courses appear at bottom of instrument.

FIRST ADJUSTABLE-PITCH WEED CUTTER is claimed for this self-propelled model by Roof Mfg. Co. Blade pitch can be varied seven degrees downward from horizontal, adapting to height of weeds or grass and providing more effective cutting job. Blade guard permits cutting within 1/4-in. of fences and buildings. Special 26-in. rotary-blade attachment is available for heavy-duty lawn mowing; 20-in. saw blade can be attached to clear trees and brush. Unit is powered by 1-cylinder, 4-cycle engine.



PHOTOGRAPHING SMOKE RINGS is part of a jet-engine noise-suppression study at Douglas Aircraft Co. Visual reference to severe air turbulence created by exhaust enables engineers to correlate geometric properties of exhaust with sound. Jet blast is made visible by injecting mineral oil in upstream air supply. Light source for photography is 5000 w incandesecent spotlight masked to produce a light slice approx. 1/2-in. wide. Light is passed through smoke perpendicular to jet axis and moved downstream as pictures are snapped.

TORRINGTON *TAPERED ROLLER* BEARINGS



Accurately caged... to cut your costs!

The one-piece, cast-bronze cage you see above is one of the reasons why TORRINGTON Roller Bearings give long, low-cost service. Note the individual roller retainment, for example. This helps keep the rollers thoroughly lubricated at all times. Race surface inspection is simplified. The machined pads in each roller pocket make sure the rollers are guided accurately at the pitch line. All this to minimize wear... lengthen bearing life.

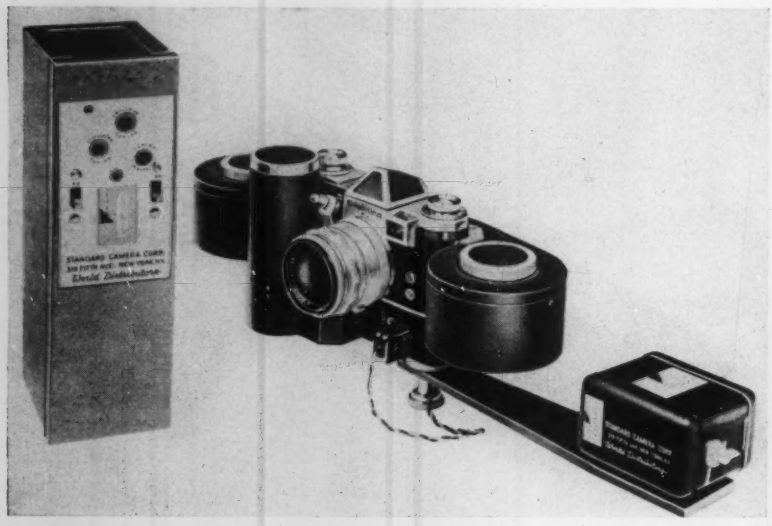
Yes, TORRINGTON Roller Bearings cut your costs. They're made of the finest bearing quality steel available, heat-treated by the most modern methods. No wonder they're so rugged... so dependable. Specify TORRINGTON *Tapered* or *Cylindrical* Roller Bearings for heavy loads and low maintenance.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

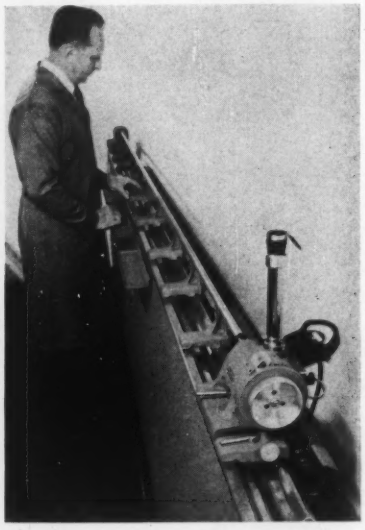
TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller Needle • Ball • Needle Rollers

Circle 409 on page 19



RADIO-CONTROLLED 35-mm camera said to be first available commercially. Radio receiver and electric motor attached to camera are activated by transmitter at distances to one mile. Photographs are taken selectively by manual operation of transmitter, or mechanically with cycling timers. Radio-control unit can be set up to operate a number of cameras from same transmitter. Special 50-ft film magazine will take 420 exposures. Standard film rolls take 20 to 36 pictures. "Praktina FX" camera and control accessories, available separately, are products of Standard Camera Corp.



LONGER INSPECTIONS are possible with this 12-ft measuring machine built by Pratt & Whitney Co. Readings to 10^{-5} in. will aid in precise inspection of jet engine parts. Hairline 1-in. divisions on master bed are visible through attached 75-power microscope. Headstock is direct reading, repeats to 10^{-5} in. accuracy. Pressure control, vital to precise measurement, is obtained through Electrolimit tailstock providing 1 to 2½ lb pressure.

PILOT TO TOWER flight information will be transmitted automatically at flick of a switch with this system developed by Stromberg-Carlson. Thirteen categories of data, including altitude, airspeed and flight time remaining can be transmitted by pilot in 2 seconds. Teletypewriter in ground control center can spell out entire message in 20 seconds for correlation with data from other planes in immediate vicinity.

Largest Solar Furnace To Produce 6000 F Heat

Unit Will Aid Research; Commercial Uses Limited

PITTSBURGH, PA.—Clean heat at extremely high temperatures will be available for research through a new solar furnace to be constructed by the Defense Dept. Largest in existence, the furnace will consist of a flat heliostat mirror more than 100 ft in diameter, pivoted and swiveled to track the sun. Rays will be reflected on a parabolic mirror of equal size and converged into the focal spot. An adjustable shutter will control quantity of reflected rays and regulate temperatures to 6000 F in a testing chamber at the focal spot.

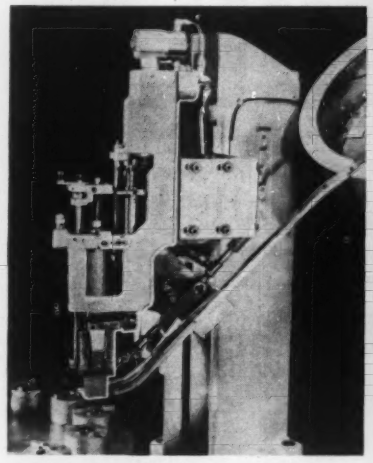
To be constructed in New Mexico by Pittsburgh-Des Moines Steel Co., the furnace will be available to private industry as well as various governmental agencies.

Some aspects of solar energy in commercial and domestic applications were discussed in a recent ASME paper by J. I. Yellott, director of the Association for Applied Solar Energy. According to Mr. Yellott, production of electricity through solar radiation is not yet encouraging. Heat collection surfaces must be too large per kw of capacity. From 50 to 150 sq ft of heating surface is needed to produce 1 kwhr. Direct conversion of sunlight into electricity, possible now at about 12 per cent efficiency with silicon solar cells, also is not feasible economically.

Most attractive use of solar radiation at present is supplying energy for residential needs. Moderate temperatures required for household appliances can be supplied with heat collected from simple flat plate devices. Where fuel costs are high and sunshine abundant, solar heating is already competitive.

Cooling and refrigeration systems are likewise promising. When chemical or other heat-operated

equipment can be produced economically, solar cooling systems may prove desirable in many regions.



STANDARDIZED DESIGN is outstanding feature of this small automatic parts positioner. Necessary tooling, electrical and mounting work are said to be simplified for variety of applications. Unit handles parts ranging in size from 1/16 to 3 in. OD at rates to 7200 per hour. Developed by Dixon Automatic Tool Co., machine is 21 in. high, 3 in. wide, 5 in. deep.

Find Studies Needed to Adapt Men to Automated Machines

Air Force Tests to Find How Long Men Can Fly Confined

DAYTON, O.—Extensive studies must be made of the adaptability and stamina of human beings under stress and strain conditions in environments created by automation. Then designers will have needed data by which to tailor machine controls to human operators or to indicate in what areas humans might develop more competence. This was the recent observation of H. A. Toulmin, Jr., board chairman, Commonwealth Engineering Co.

"It takes a human brain to design an automatic system and to

(*Continued on Page 22*)

DRAFTING TRENDS

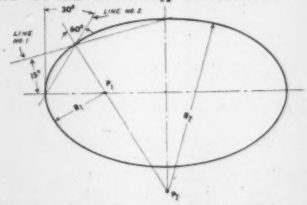
This free booklet, newly developed by the Frederick Post Company through the co-operation of leading engineers and draftsmen, shows 59 shortcuts to speed drafting and computation work.

Ideas for increasing drafting and engineering efficiency

POST went to leading engineers and draftsmen and asked them what techniques they use to save time without sacrificing precision in their work. From the many interesting tips and drafting shortcuts suggested, a total of 59 have been compiled into one handy booklet called "Time Saving Tips for the Draftsman and Engineer."

Clearly written and well illustrated, this booklet shows new approaches to old problems. The section on CALCULATING IDEAS contains 10 tips including easy ways of "Remembering the Signs of Trig Functions," "Dividing a Circle Into Parts," and "Locating Decimal Points."

One of 22 Drafting Shortcuts



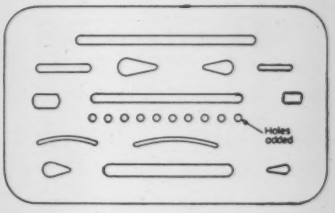
Here is what seems to be the fastest and easiest method of constructing an approximate ellipse: (1) Draw a line at 15° to major axis as shown. (2) Draw a line at 30° to minor axis as shown. (3) Draw a line at 60° to line #2 through intersection of lines #1 and #2. (4) Draw Arc R_1 from point P_1. (5) Draw Arc R_2 from point P_2.

9 tips in Engineering Data Section

Easy-to-use, practical shortcuts to formulas and other engineering data are featured in this section. Two of these time savers are faster methods of "Determining Gear Inertia" and "Interpolating Between Family of Curves."

One of 18 Board Timesavers

Fairly often when drafting it becomes necessary to change a solid line to a dotted line. By placing a series of holes in an erasing shield, as shown, it is possible to make the conversion simply by erasing through the holes.

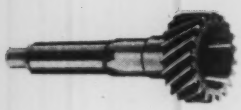


For your free copy of "Time Saving Tips for the Draftsman and Engineer," contact your POST dealer or write today to the Reader Service Division of Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

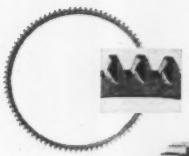
POST

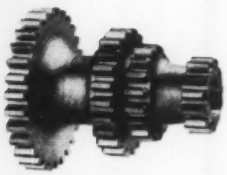
SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

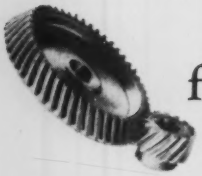
DOUBLE DIAMOND GEARS ARE BUILT...

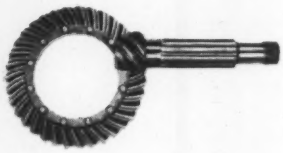


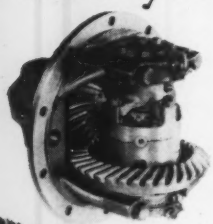
...to produce low installed cost

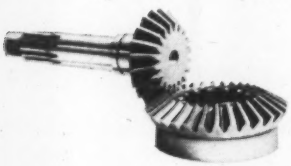
...to serve economically  and

dependably on the job 



for which you buy them 

...and to do  credit to your product

and reputation 

The gear types shown above include helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts. Those are the types in which we specialize. Our sales people are gear engineers. Would you like to talk to one?

* Reg. U. S. Pat. Off.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 411 on page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Actuators, Adv. 138
Adhesives, Adv. 51
Automobiles, Edit. 6
Axles, Edit. 94; Adv. 28

Batteries, Edit. 5
Bearings, ball, Edit. 130, 154
  needle, Adv. 119
  rod-end, Adv. 178
  roller, Adv. 13, 40
  sleeve, Adv. 9, 152, 177
Bellows, Edit. 152
Belts, transmission, Adv. 2, 121, 136
Blowers, Adv. 62
Books, Edit. 171
Brass (see Copper and alloys)
Bronze (see Copper and alloys)

Carbides, cemented, Adv. 150
Carbon and graphite parts, Adv. 34
Castings, Adv. 152
  die, Adv. 157
  high alloy, Adv. 135
  investment, Adv. 143
  iron, Adv. 68, 155
  permanent mold, Adv. 68
  steel, Adv. 36
Chain, transmission, Adv. 55, 61, 181
Circuit breakers, Edit. 130, 166; Adv. 48
Classified ads, Adv. 182
Clutches, Adv. 37, 160
Coatings, protective, Edit. 132
Compressors, Adv. 126
Computers, Edit. 167
Contactors, Adv. 113
Contacts, Edit. 164
Contracts, employment, Edit. 80
Control systems, electric, Edit. 95, 128; Adv. 182
  hydraulic, Edit. 96
Controls, automatic, Adv. 182
  electric, Edit. 158; Adv. back cover
  pneumatic, Edit. 160; Adv. 39
Copper and alloys, Adv. 60, 152
Corrosion-resistant alloys, Adv. 60
Counters, Edit. 138
Couplings, fluid, Adv. 169
  shaft, Adv. 31, 66, 139
Cutters, cable, Edit. 143
Cylinders, Edit. 136
  hydraulic, Adv. 7, 125
  pneumatic, Adv. 125

Drafting equipment, Edit. 167; Adv. 11, 15, 38, 179, 180
Drives, adjustable speed, Adv. 171

Electric equipment (see specific type)
Electronic components, Edit. 25, 114
Engines, Edit. 134; Adv. 59

Facilities, general, Adv. 175
Fasteners, Adv. 180
  blind, Adv. 42, 45
  bolts, nuts, screws, Edit. 128, 140, 156; Adv. 45, 50, 117, 153, 158, 165, 179, 182
  insert, Adv. 156
  pin, Adv. 168
  rivet, Adv. 42
Felt, Adv. 142
Finishes (see Coatings)
Fittings, pipe, tube and hose, Edit. 178; Adv. 24, 30, 148
Forgings, Adv. 147

Gages, pressure, etc., (see Instruments)
Gaging equipment, Adv. 122
Gear blanks, Edit. 150
Gear shaping, Adv. 43
Gears, Edit. 78, 110, 176; Adv. 16, 35, 148, 151, 163
Generators, electric, Edit. 140, 156

Heat-resistant alloys, Edit. 108
Hose, metallic, Adv. 4
  nonmetallic, Adv. 148

Increasers, speed, Adv. 151
Induction heating, Adv. 176
Instruments, Edit. 132, 150, 152, 168; Adv. 25

Jacks, worm gear, Adv. 138

Lighting, Edit. 10, 163
Lubrication equipment, Adv. 173

Machines (see specific type)
Management, engineering, Edit. 72, 80, 103
Mask, protective, Edit. 6
Meetings, Edit. 25, 31
Metals (see specific type)
Motion-resisting forces, Edit. 98; Adv. 105
Motors, electric:
  fractional and integral hp, Edit. 163; Adv. 52, 54, 56, 63, 67, 133
  subfractional hp, Adv. 167
Mountings, vibration and shock, Edit. 164; Adv. 141

Packings, Adv. 34
Pipe, Adv. 44
Plastics, Adv. 58, 127, 166
Pneumatic equipment (see specific type)
Potentiometers, Edit. 79
Powder metallurgy, Adv. 9, 32, 132, 157
Pulleys (see also Sheaves), Adv. 121
Pumps, Edit. 143; Adv. 69, 134, 137, 164
  pneumatic, Adv. 145

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Reducers, speed, Edit. 160; Adv. 154, 163
Regulators, pressure, Adv. 21, 147
voltage, Edit. 134
Relays, Edit. 128, 142, 148; Adv. 180
Research and development, Adv. 131, 146, 172
Resistors, Edit. 158
Rings, welded, Adv. 115
Rubber, Edit. 142; Adv. 53, 170, 179

Seals, Edit. 79, 128, 136; Adv. 34, 177
Servos, Edit. 89
Shafts, Adv. 129
flexible, Adv. inside front cover, 162
Sheaves (see also Pulleys), Adv. 136
Silicones, Edit. 142; Adv. 179
Solar furnace, Edit. 14
Spindles, Adv. 28
Springs, Edit. 105
Sprockets, Adv. 61, 181
Stampings, Adv. 29
Starters, engine, Adv. 111
Steel, Adv. 23, 47, 64, 147
stainless, Adv. 135, 144
Switches, Adv. 130
Swivel joints, Edit. 138, 176

Tachometers, Edit. 162
Testing, Adv. 146
Thermostats, Adv. 161
Timers, Edit. 146, 155; Adv. 46, 124, 181
Tips and techniques, Edit. 77, 82, 93, 104
Torque converters, Adv. 70, 140
Transducers, Edit. 178
Transformers, Edit. 145
Transmissions, adjustable speed, Edit. 83; Adv. 130, 136, 159, 168, inside back cover
Trim, adhesive, Edit. 146
Truck body, elevator, Edit. 8
Trucks, Edit. 10
Tubing, Edit. 145, 163; Adv. 44, 122
Turbines, gas, Edit. 28
Turnbuckles, Edit. 128

Universal joints, Adv. 129

Valves, Edit. 128, 148, 155; Adv. 1
pneumatic, Edit. 160; Adv. 39
Vehicles, mechanics of, Edit. 98

Wear-resistant alloys, Adv. 27, 36, 60
Welding, Adv. 115
Wheels, Adv. 28

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 118

	ITEM NUMBER
Coil & Sheet Slitters	571
Spiral Bevel Gears	572
Polyethylene	573
Lubricant Tester	574
Thermocouple Tubing	575
Beryllium Copper Parts	576
Regulated Power Supplies	577
Multiconductor Cable	578
Chemical Milling	579
Weld Fasteners	580
Epoxy Adhesives	581
Filtration Sheets	582
Cycling Drive Unit	583
Industrial Liquid Meter	584
Timers & Relays	585
Electrical Connections	586
Pressure Pickup	587
Water & Steam Hose	588
Thermocouple Assemblies	589
Drawing-Blueprint File	590
Potentiometer	591
Electrical Relays	592
Variable Speed Drives	593
Precision Switches	594
Plug-in Busway	595
Leaded Alloy Steel	596
Oil Seals	597
Electrical Connectors	598
Aircraft Thermocouples	599
V-Belt Drives	600
Adjustable Thermostat	601
Electric Coils	602
Cadmium Brightener	603
Stainless Steels	604
Oil Seals	605
Liquid Chillers	606
Tank Heaters	607
Hardness Testers	608
Electrospark Machining	609
Wet Mixing Equipment	610
Steam Traps	611
Alloy Steel Plate	612
Nuclear Welding	613
Jet Aircraft Instruments	614
Ferrite Magnetic Materials	615
Heat Treating Accessories	616
Optical Height Gage	617
Polyethylene Ware	618
Gravity Storage Rack	619
Pneumatic Conveyors	620
Carbides	621
Eyelet Parts	622

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 128

	ITEM NUMBER
Photoelectric Relay	623
Short Turnbuckle	624
Shaft-Mounted Gearmotor	625
Fastener-Seals	626
Swing Check Valve	627
Circuit Breaker	628
Ball Bearings	629
Read-Out Device	630
Powdered Chromate Coating	631
Industrial Engine	632
Voltage Regulator	633
Cylinders	634
Pipe Fitting	635
Pushbutton	636
Magnetic Counters	637
Locknuts	638
Motor-Generator	639
Polar Relay	640
Silicone Rubber	641
Cable Cutter	642
Industrial Coolant Pump	643
Kel-F Tubing	644
Variable Transformer	645
Self-Adhesive Trim	646
Timing Motor	647
Solenoid Valve	648
Subminiature Relay	649
Gear Blanks	650
Shaft Position Transmitter	651
Flattened Bellows	652
Code Disks	653
Motor Base	654
Ball Bearings	655
Sequence Programmer	656
Globe Valve	657
Nuts and Lock Washers	658
Heavy-Duty Generator	659
Miniature Resistor	660
Shaft Disconnects	661
Control Valves	662
Speed Reducers	663
Digital Tachometer	664
Pilot Light	665
Extruded Tubing	666
Shaded-Pole Motor	667
Electrical Contact Rings	668
Vibration Isolators	669
Circuit Breaker	670
Template Kit	671
Bow Compasses	672
Computing Device	673
Strain Indicator	674
Force Pickups	675
Screw Selector	676

MACHINE DESIGN
JULY 25, 1957

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 25, 1957

MACHINE DESIGN
JULY 25, 1957

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 25, 1957

MACHINE DESIGN
JULY 25, 1957

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 25, 1957

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

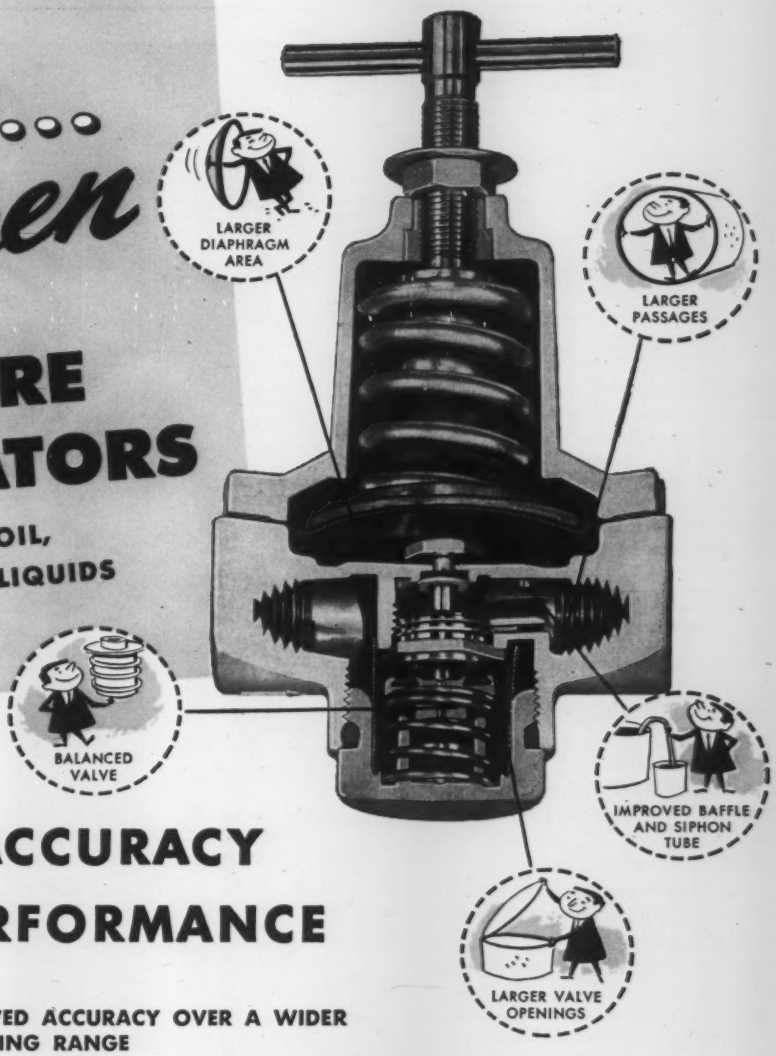
Reader's Service Dept.

NEW...

Norgren

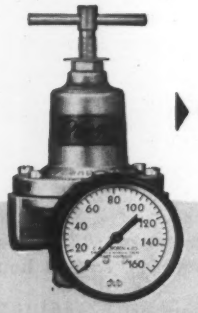
PRESSURE REGULATORS

FOR AIR, WATER, OIL,
NON-CORROSIVE LIQUIDS
AND GASES



GREATER ACCURACY
BETTER PERFORMANCE

- **IMPROVED ACCURACY OVER A WIDER OPERATING RANGE**
- **GREATER ACCURACY OF REGULATED PRESSURE** even with widely fluctuating line pressure and rapidly varying flow.
- **LARGER FLOW CAPACITY**
  - a. Balanced Valve Construction
  - b. Greater Effective Diaphragm Area
  - c. Improved Baffle and Siphon Performance
  - d. Larger Passages
  - e. Larger Valve Openings
- **RELIEVING AND NON-RELIEVING TYPES AVAILABLE FOR AIR**

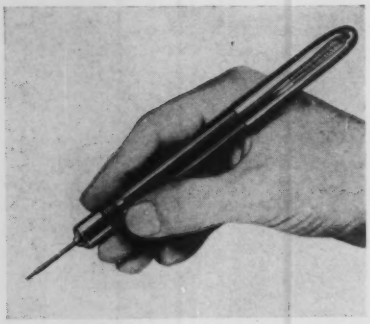


For complete information on all your regulator needs, ⅛" to 2" inclusive, call your nearby Norgren Representative listed in your telephone directory — or WRITE FACTORY FOR LITERATURE.

C. A. NORGREN CO.

3442 SO. ELATI STREET • • • ENGLEWOOD, COLORADO

Circle 412 on page 19



FOUNTAIN-PEN OILER will deliver exact amounts of oil in fraction-of-drop quantities. Oil is ejected by pressure and release of unit's spring steel point against surface to be oiled. The oiler will operate in either vertical or horizontal position. It is a product of Dill Mfg. Co.

(*Continued from Page* 15)

formulate the problems to be fed through it. It takes a human being to control it and a human being to operate it.

"All are possessed of the frailties of physical and phychological makeup, frailties that constitute limiting factors in the effective application of automation.

"For instance, we have problems of thumb, index finger, hand, elbow, shoulder, eyes, ears, the hearing and even the sense of smell. All are elements of the human body so vital to automation that it could not function without them. Visual acuity in reading instruments, for example, is vital. Where colored buttons, wires and instruments and liquid indicators are used, color blindness would be fatal.

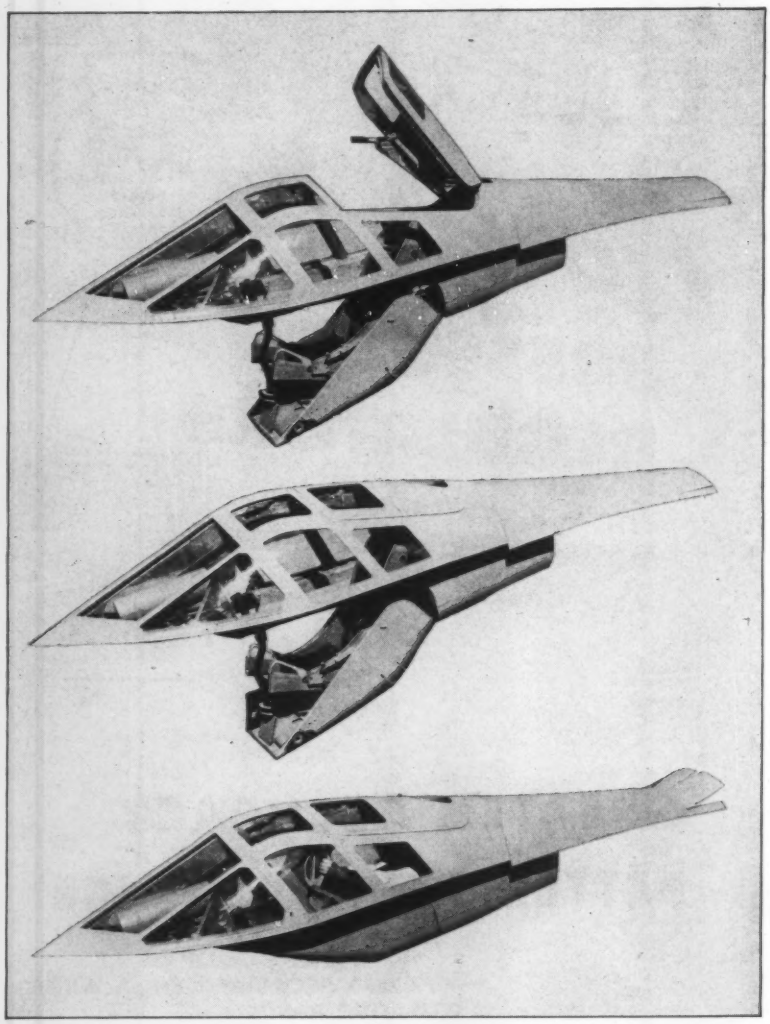
"With automation we must also take into account noise, and its counterpart, silence; changes in temperature and pressure; the presence of gases, drafts, vibrations; and the effects of radiation.

"The psychological phase of the problem is, of course, even more difficult. Continuous watching of instruments is not an easy thing to do. Observing the dials and other indicators of an operation for considerable periods of time can easily lead to carelessness.

"To meet these problems of human limitations, we must design control equipment in the light of extended psychological and physical studies."

One such investigation for the Air Force is currently under way at Lockheed Aircraft Corp. In a full-scale mock-up of a flight station, five-man crews will be confined for periods up to 120 hours each.

The men will "fly" the plane, operating dummy controls simu-



CANOPY CAPSULE for single-place, supersonic, fighter aircraft will bring 'em back alive from any altitude, very high or moderate, to any surface, land or water. Pilot-escape vehicle, developed by Stanley Aviation Corp., consists of plane's windshield, cockpit canopy with normal entrance hatch and pilot's seat. It carries its own parachutes, pilot survival gear and the plane's upper main instrument panel. Capsule retains high-altitude cockpit pressure, will float indefinitely in water. Pilot may ride the capsule to earth or go it alone through hatch when speed and altitude permit.

Sequence of events in the escape operation begins when pilot's legs are jackknifed by coordinated operation of a bar across the seat and a foot retraction system. Seat then folds back into jaw-like door which closes to form capsule bottom. Door closure frees capsule from fuselage, ignites ejection rocket. Freed from plane, capsule releases drogue parachute which helps stabilize and decelerate the vehicle, and aids in sensing dynamic pressure. At reduced speed and below preset altitude, drogue deploys main recovery parachute. Rate of descent is said to be comparable to velocity of ordinary parachute landing.

INTRODUCING GRAPH-AIR...

a tougher, more versatile graphitic tool steel that air-hardens at temperatures 200° to 300° lower with less distortion!

NO facilities for oil-quenching—or other relatively costly heat treating processes? Need a finer air-hardening tool steel? Then specify *Graph-Air,* newest steel resulting from the Timken Company's pioneering in fine alloy steels. Latest addition to our line of quality graphitic tool steels!

Graph-Air tool steel air-hardens at temperatures of 1450°F to 1550°F—200° to 300° lower than most other air-hardening tool steels. And because Graph-Air *is* air-hardened, there's less distortion, easier heat treating control, less decarburizing. As a result, Graph-Air can be made into *more intricate sections.* Graph-Air is a tough air-hardening steel, too—made to order for such demanding applications as blanking dies, or any tool steel part which must take hard abuse.

Besides all the advantages of air-hardening—economy, less drastic reactions to quenching, less tendency to scale—Graph-Air offers greater wear, machinability and stability. Like Graph-Mo, Graph-Air will outwear other tool steels, because of the uniform diamond-hard carbides in its structure. Graph-Air stays *accurate longer,* is fully as stable as other Timken Company graphitic tool steels, which are the most stable tool steels made!

Growing out of the Timken Company metallurgists' long experience with fine steel making, Graph-Air—the *new* graphitic tool steel that can be air-hardened at *low* temperatures—will be available in both solid and hollow bar sizes. For more information, write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

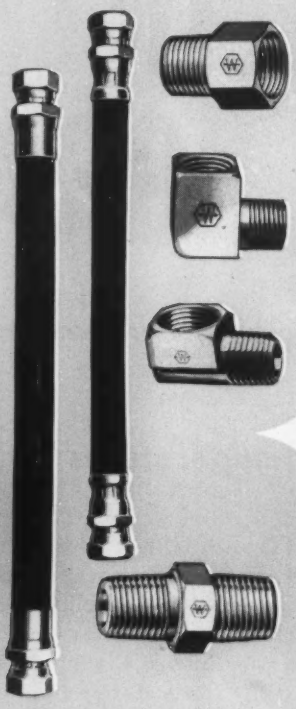
TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 413 on page 19

"WEATHERHEAD PRODUCTS add to the reliability and success of our Kab-Kooler"

says Mr. R. L. WESTRUM, *Design Engineer*,
D. W. Onan & Sons, Inc.,
Minneapolis, Minn.



Weatherhead refrigeration components, brass and steel tube fittings, hose ends and hose assemblies.

What about the products you manufacture . . . or are planning to produce? There's the possibility that Weatherhead will fit into your picture, too . . . just like Onan's.

WEATHERHEAD
FIRST IN HYDRAULIC CONNECTIONS

THE WEATHERHEAD CO., FORT WAYNE DIVISION
Dept. AB-7, 128 West Washington Blvd., Fort Wayne, Indiana
In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario

The new Onan Kab-Kooler is a dependable air-conditioning package designed specifically to provide air-cooling, air-circulation and dehumidifying for the comfort of the truck cab occupants.

Circle 414 on page 19

lating emergency and normal flight conditions. They will eat, sleep, work, and relax in this tiny area. Ten crews will be used during the experiment, to be concluded early in 1958.

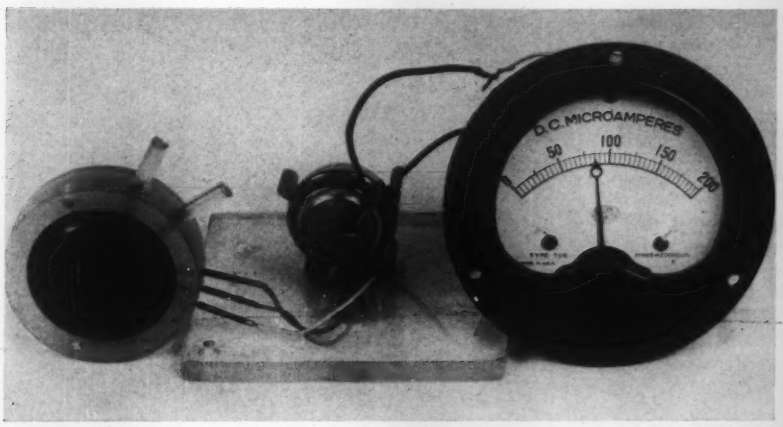
Plans Under Way for Fourth Mechanisms Conference

CLEVELAND, O.—Well advanced in the planning stage is a Fourth Conference on Mechanisms to be sponsored by the School of Mechanical Engineering of Purdue University and MACHINE DESIGN.

Dates of the Fourth Conference on Mechanisms are Monday and Tuesday, October 14 and 15.

Success with the first three conferences in 1953, 1954 and 1956 has guided planners of the fourth in arranging for papers of direct concern to design engineers.

The planning committee is composed of industry members and representatives of the sponsors. Planning cochairmen are A. S. Hall of Purdue and Benjamin L. Hummel of MACHINE DESIGN.



Solion (left) sensitive, low-powered, electrochemical, activates electrical circuits. Silver-cell battery (center) 0.9 v, 1½ amp, has life of 10-15 years.

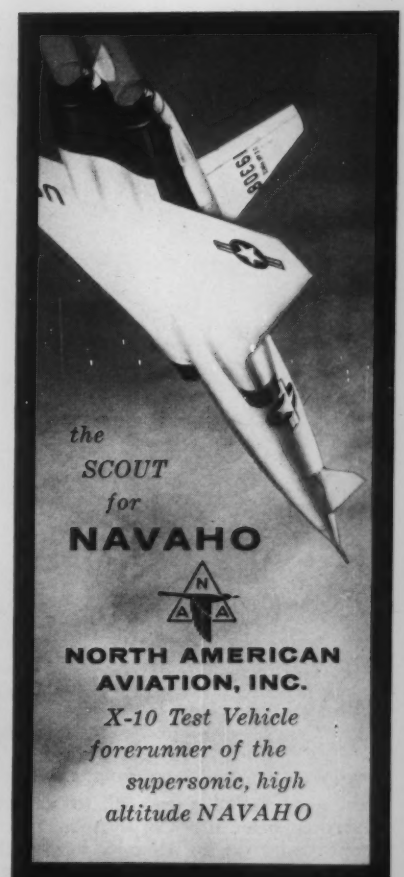
Electrochemical Device May Challenge Tubes, Transistors

Small Reliable Power Source Answers to Variety of Forces

WASHINGTON, D. C. — Miniature electrochemical devices developed by Naval Ordnance Lab. may challenge vacuum tubes and transistors in a wide variety of electronic applications. Called Solions, the low-power, highly sensitive devices are said to make transistorized circuitry appear complicated.

Principle of operation is simple. Current is generated by movement of ions between electrodes in a chemical solution, after being excited initially by a dry-cell battery. Current is then sustained and varied through stimulation of the unit by temperature, pressure, light, sound or acceleration.

Test models of an electrochemical flight integrator, already produced industrially under Navy contract, demonstrate simplicity and accuracy of the new components. The navigational instrument — no larger than a baseball—operates on inertia principle. Once started in motion in one direction, it possesses what amounts to memory of its original course and instantly senses directional change in three dimensions. Integrator mechanism consists of a small cylinder divided in two sections by a porous ceramic filter. Its two electrodes are immersed in potassium iodide solution. Any change in direction of movement causes measurable change in current output, and this



IN THE X-10,
Statham transducers gathered pressure and acceleration data in North American Aviation's program to prove out the aerodynamic design as well as the guidance and control systems for NAVAHO.

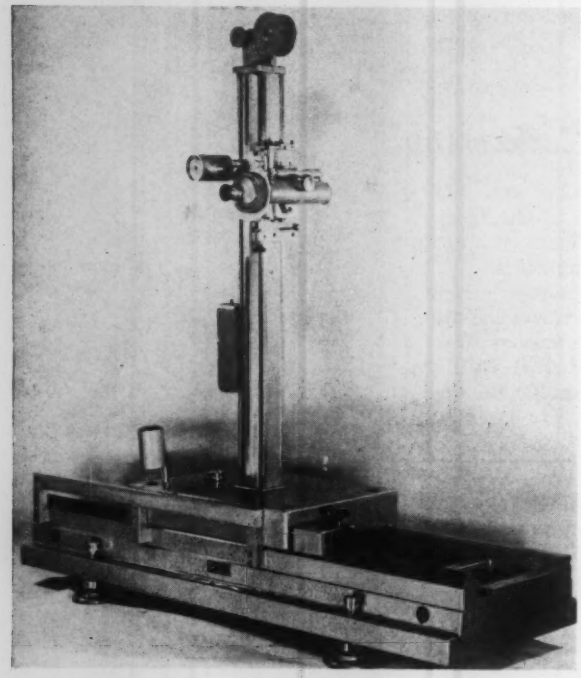
WHEN THE NEED
IS TO KNOW... FOR SURE
SPECIFY STATHAM

Accelerometers
Pressure Transducers
Load Cells

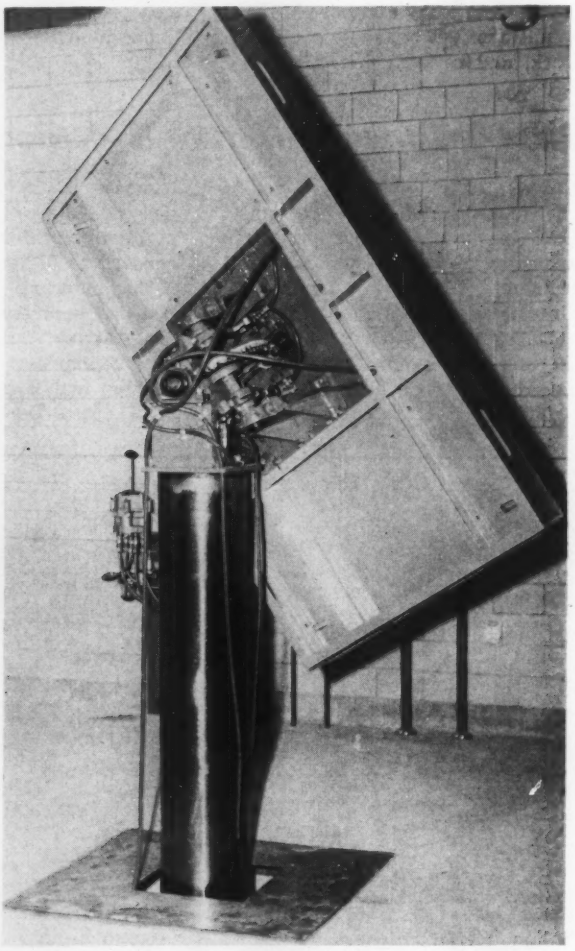
Catalog, complete with prices, available upon request.

Statham
LABORATORIES
LOS ANGELES 64, CALIFORNIA

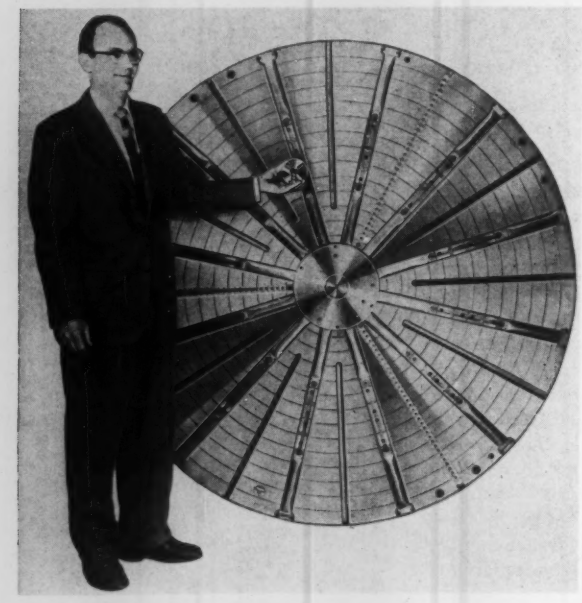
Circle 415 on page 19



TWO READINGS AT ONCE is the capability of this new gage called a co-ordinate cathetometer, made by Gaertner Scientific Corp. A microscope or telemicroscope slides on an accurate vertical bar. Bar assembly then moves horizontally on precision ways.



OPERATIONS ON ANIMALS are made more convenient for veterinarians with this table which can travel vertically, turn about its vertical axis, and tilt in two planes. The table is installed in Cornell University's Veterinary College. A 4 by 6-ft stainless surface with straps and cleats for animal tie-down is mounted atop a garage-type air-hydraulic lift. Tilt is accomplished by self-locking worm gear halves driven by air motors of 0.65-hp max. Package 7 in. long, 2 in. in diameter houses the motors and permits table to be lowered to 16 in. above floor.



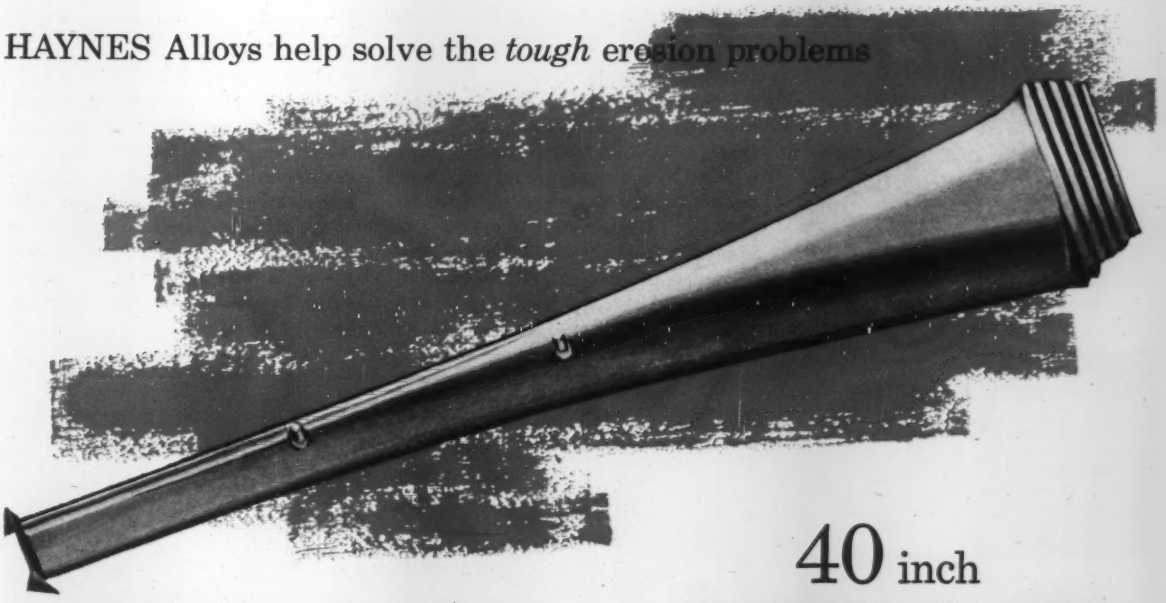
Left

LARGEST LATHE CHUCK made by Horton Chuck Div., Greenfield Tap and Die Corp., is intended particularly for machining jet-engine components to high accuracy. The 66-in. diam. chuck accommodates thin-walled rings with a controlled centering pressure device. Three jaws move in, stop automatically on contact. Twelve more jaws then grip the part firmly.

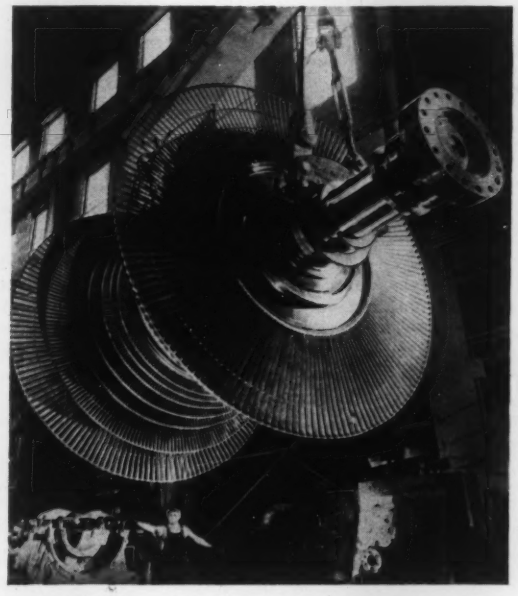
in turn activates proper control devices. Correct heading is instantly re-established. Present electronic integrators are far more complex, take up considerable space and weigh several hundred pounds.

Another control mechanism can replace present metallic types of thermostats to control furnace

HAYNES Alloys help solve the *tough* erosion problems



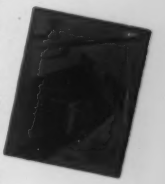
40 inch TURBINE BLADES Protected Against High-Velocity Erosion



...Two rows of 40-inch blades are shown on this double-flow, low-pressure steam turbine spindle. A 27-in. strip of HAYNES STELLITE alloy has been silver-soldered on each blade as protection against high-velocity erosion.

Blading at the cold end of modern condensing-type steam turbines is subjected to severe erosion. Rim speed of some turbines approaches that of a high speed bullet—even small water particles can cause rapid wear on most metal parts at these high velocities.

Yet when the leading edges of these blades are protected with shields of HAYNES STELLITE alloy, they remain in operation for as long as 19 years! This dramatic example of ruggedness is one of the reasons HAYNES cobalt-base alloys are used in many industries to solve abrasion and erosion problems.



For information on long-wearing and erosion resistant alloys, send for our Booklet. Write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

UNION CARBIDE

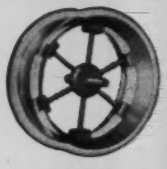
"Haynes," "Haynes Stellite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 416 on page 19

ELECTRIC
Wheels · Axles · Spindles

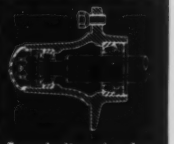
DIVIDED WHEELS
Generally used as dolly, tail or caster wheels

FOR TRUCK TIRES
Full drop center rim to utilize used truck tires on larger implements

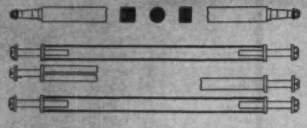


PLANTER WHEELS
Steel rim or for use with planter rubber tires

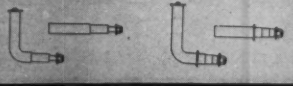
SIX BOLT SERIES
Light and heavy—widest range of implement use



Four bolt series for light implements



Hub and bearing combinations available. Stub spindles and full length axles.



Our Engineers Invite Your Inquiries

ELECTRIC WHEEL COMPANY
DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY
2809 SPRUCE · QUINCY, ILLINOIS

Circle 417 on page 19

and room temperatures. The instrument detects rate at which given temperature change is taking place, rather than sensing that change has already occurred. Tendency to overshoot or undershoot desired temperature range is eliminated. Unit can be made sensitive enough to react to heat of human body, to practically any light source in its vicinity, or to very mild pressure.

Sound exposure meter to measure cumulative exposure of personnel to jet engine noise is also being developed by the Navy. Fluid in the electrochemical unit gets darker as it is exposed to high intensity sound. Person wearing the meter is warned when color indicates exposure to a predetermined amount of sound.

NO OPERATOR rides on this "robot" earth-mover now being tested by the Army. Radio controls mounted in a jeep or helicopter control the vehicle from distances to 15 mi. All normal operations can be performed. Next step in testing is installation of small television sets to eliminate need of visual observer. Vehicle should prove valuable for construction work in radioactivated and combat zones, and for fighting large fuel storage fires. Prototype is a standard Le Tourneau-Westinghouse Tournadozer. Manual controls have been retained for conventional operation.

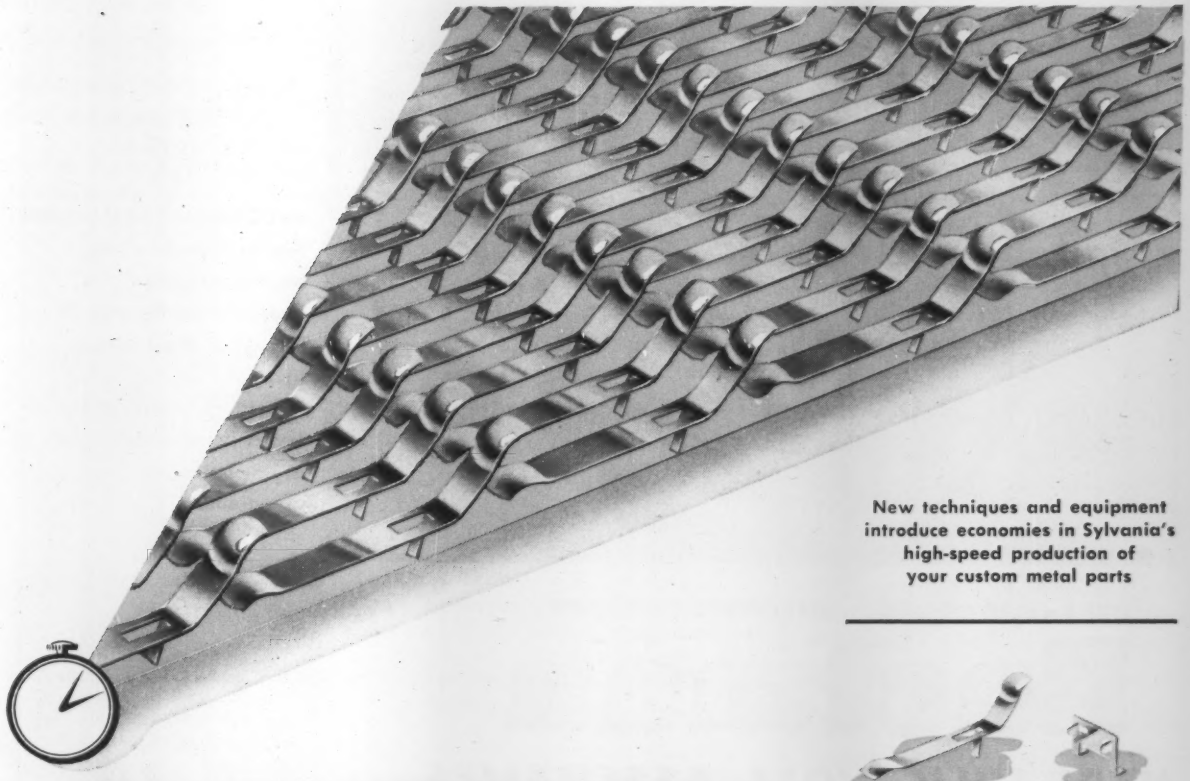
Lightweight Gas Turbine To Power Army Generators

FT. BELVOIR, VA.—New gas-turbine engine, weighing approximately one-tenth as much as industrial diesel or gasoline engines of comparable performance is being developed by the Army. Unit will meet Army's requirement for a prime mover in lightweight, 400-cycle, 100-kw engine-generator set, and other applications where portability is necessary.

Designed to produce 170 hp under extreme environmental conditions, it will be capable of producing 286 hp at 60 F and sea level conditions. Future growth potential to 389 hp has been included in original design, and enventual improved fuel economy to 0.557 lb per bhp-hr through use of regenerator is anticipated.

Present output shaft speed is 12,000 rpm, but interchangeable gearing will permit wide choice of speeds. Provision for modification to a free-turbine type engine was included in original design for applications having heavy starting loads and variable speeds.

Product of the Corps of Engineers and AiResearch Mfg. Co., the engine is 44 in. long, 31 in. wide, 24 in. high, weighs 326 lb. It is designed for 1000 hr of life between overhauls.



New techniques and equipment introduce economies in Sylvania's high-speed production of your custom metal parts

100% increase
from 10,000/hr.
to 20,000/hr.

150% increase
from 8,000/hr.
to 20,000/hr.

57% increase
from 7,000/hr.
to 12,000/hr.

187% increase
from 8,000/hr.
to 15,000/hr.

57% increase
from 7,000/hr.
to 12,000/hr.

33% increase
from 6,000/hr.
to 8,000/hr.

More parts per hour

means lower cost per part

To THE DESIGNER or buyer of precision small parts these case histories of greater production speeds imply substantial economies—particularly on long-run, volume parts.

Secret behind this exciting news is new Sylvania equipment designed and built by Sylvania on the multi-slide principle to produce complex parts which normally might be stamped on conventional presses at lower speeds.

This Sylvania equipment has been added to complete metal stamping facilities which include multi-slide equipment, vertical presses, eyelet machines and wire formers.

Take your custom precision small parts to Sylvania where more and more efficiency-minded designers are turning not only for metal stampings but for custom-molded plastics, plated, clad and alloy wire, wire welds, and special components.

SYLVANIA PARTS DIVISION

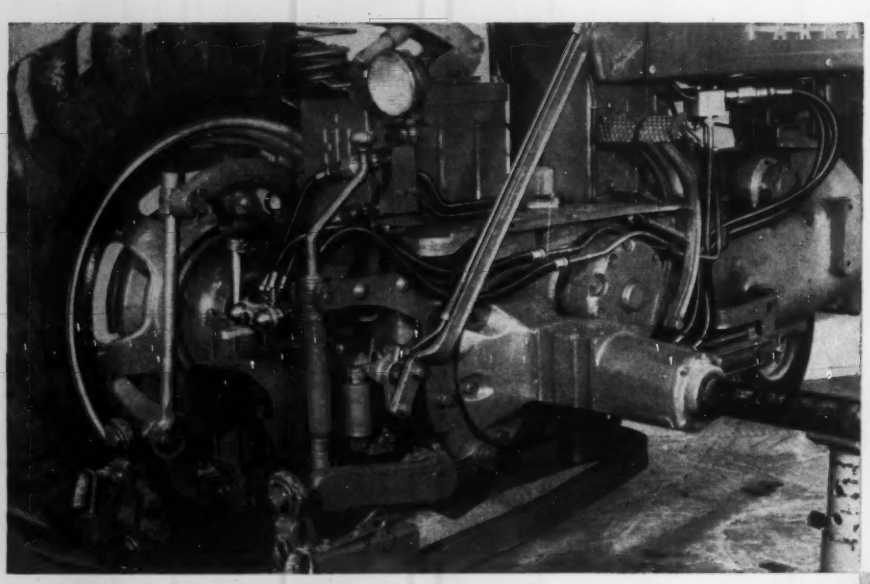
Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

LIGHTING · RADIO · TELEVISION · ELECTRONICS · ATOMIC ENERGY

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS

4-way service from one source

Circle 418 on page 19



INTERNATIONAL HARVESTER'S
McCORMICK FARMALL 400
Tractor controls every implement action hydraulically through its famous Hydra-Touch hydraulic system. Individual, closely grouped levers permit independent or unison control of cylinders.

HYDRAULIC POWER . . . DELIVERED THROUGH

Eastman

HYDRAULIC HOSE ASSEMBLIES . . .

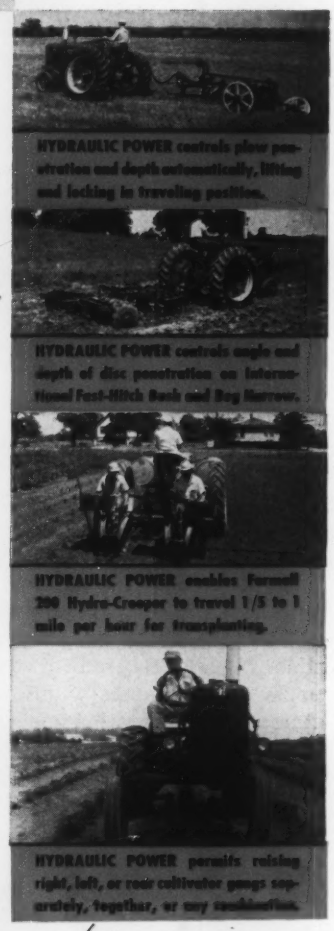
Most competitive Farm Implement Sales Feature

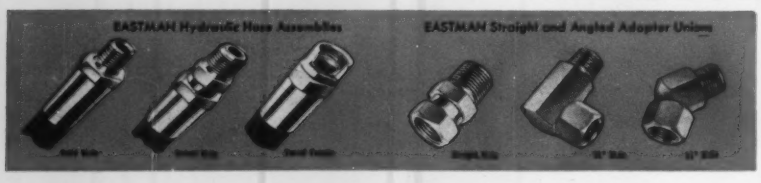
HYDRAULIC POWER probably contributed more to the usefulness, efficiency, and easy operation of farm tractors than any other modern engineering development. Farmers appreciate hydraulic advantages so much that they have become one of the *most competitive features in implement and tractor sales promotion.*

EASTMAN MANUFACTURING COMPANY is proud to have among its many agricultural users the International Harvester Company—dating back to the first McCormick Reaper—in 1831. Eastman—*first in the field* of Hydraulic Hose Assemblies—lists many other agricultural implement manufacturers among its users: J. I. Case, Allis-Chalmers, Massey-Harris-Ferguson, Inc., Minneapolis-Moline, Farmhand, Avco, and others.

IMPROVE THE COMPETITIVE POSITION OF YOUR PRODUCTS with Hydraulic Power—delivered through Eastman Hydraulic Hose Assemblies. Always specify Eastman: First in exclusive engineering advantages and design! First in materials and workmanship! *First in the field* of Hydraulic Hose Assemblies!

WRITE **Send your specifications and blueprints for our original equipment quotations.**


HYDRAULIC POWER controls plow penetration and depth automatically, lifting and locking in traveling position.
HYDRAULIC POWER controls angle and depth of disc penetration on International Fast-Hitch Rock and Rag Harrow.
HYDRAULIC POWER enables Farmall 200 Hydra-Creeper to travel 1/5 to 1 mile per hour for transplanting.
HYDRAULIC POWER permits raising right, left, or rear cultivator gangs separately, together, or any combination.



Eastman
first in the field
MANUFACTURING COMPANY
Dept. MD-7, Manitowoc, Wis.

Circle 419 on page 19

Machine Design Appoints Two Assistant Editors

CLEVELAND, O.—Clare E. Wise and Marian L. Vlasak have been named assistant editors of MACHINE DESIGN.

Mr. Wise received his B.S. degree from Hillsdale College, Hillsdale, Mich., and also took courses at the

Clare E. Wise

University of Michigan. He had previously spent two and one-half years in the Air Force, with duty involving aircraft electronics and mechanics. Before joining MACHINE DESIGN in May of this year, he was associated with the Cleveland Trust Co. Mr. Wise's present assignment is preparation of material for "Engineering News Roundup."

Marian L. Vlasak

Miss Vlasak, who was formerly an editorial assistant, joined MACHINE DESIGN in January, 1955. She is a graduate of Flora Stone Mather College of Western Reserve University. Miss Vlasak is responsible for the "New Parts and Materials" department.

Meetings

AND EXPOSITIONS

Aug. 12-15—

Society of Automotive Engineers Inc. West Coast Meeting to be held at the Olympic Hotel, Seattle. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

Aug. 20-23—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Additional information can be obtained from Wescon headquarters, 342 N. La Brea, Los Angeles 36, Calif.

Aug. 26-28—

Gas Dynamics Symposium to be held at the Technological Institute of Northwestern University. Sponsors are the American Rocket Society and the university. Further information can be obtained from Dr. Ali Bulent Cambel, Gas Dynamics Laboratory, Northwestern University, Evanston, Ill.

Aug. 28-30—

American Institute of Electrical Engineers. Pacific General Meeting to be held in Pasco, Wash. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 4-6—

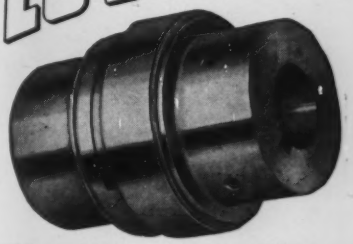
American Institute of Electrical Engineers. Magnetic Amplifiers Conference to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from institute headquarters, 33 W. 39th

(*Continued on Page* 34)

15 YEARS SERVICE WITH ONE SET OF CUSHIONS

... actual report on

LOVEJOY



Flexible Couplings

Up to fifteen years maintenance-free service is not unusual with Lovejoy lubrication-free flexible couplings.

Performance like this is practical proof of these soundly engineered features:

SIMPLE, RUGGED CONSTRUCTION
Fewer parts. No intricate mechanisms. Nothing to lubricate.

LOAD TRANSMITTED BY CUSHION COMPRESSION
No wear on the metal jaws.

DOUBLE-LIFE CUSHIONS
One half of the cushions act as idlers—except on reversible loads. A quick interchange provides a new set of cushions. This can be done without dismantling the coupling.

Illustration at right shows a Lovejoy Type CF flange-mounted coupling. Rated at 160 hp., 800 rpm., this space saver connects drive shaft between diesel power unit and generator.

You can get Lovejoy performance for your application.

Let us know your requirements or request complete-line catalog.

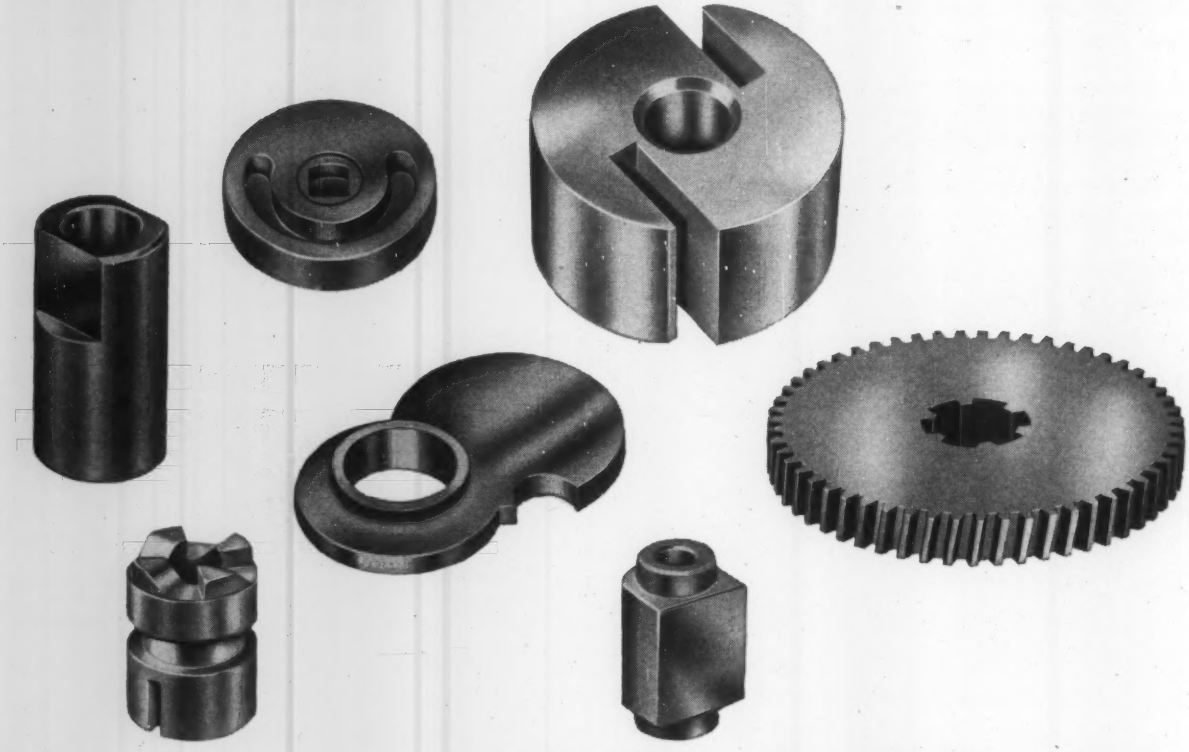
LOVEJOY FLEXIBLE COUPLING CO.

4818 W. LAKE STREET • CHICAGO 44, ILLINOIS

Mfrs. of Flexible Couplings, Variable Speed Pulleys and Transmissions, Motor Bases and Universal Joints.

Circle 420 on page 19

regardless of SHAPE...



economical GRAMIX®

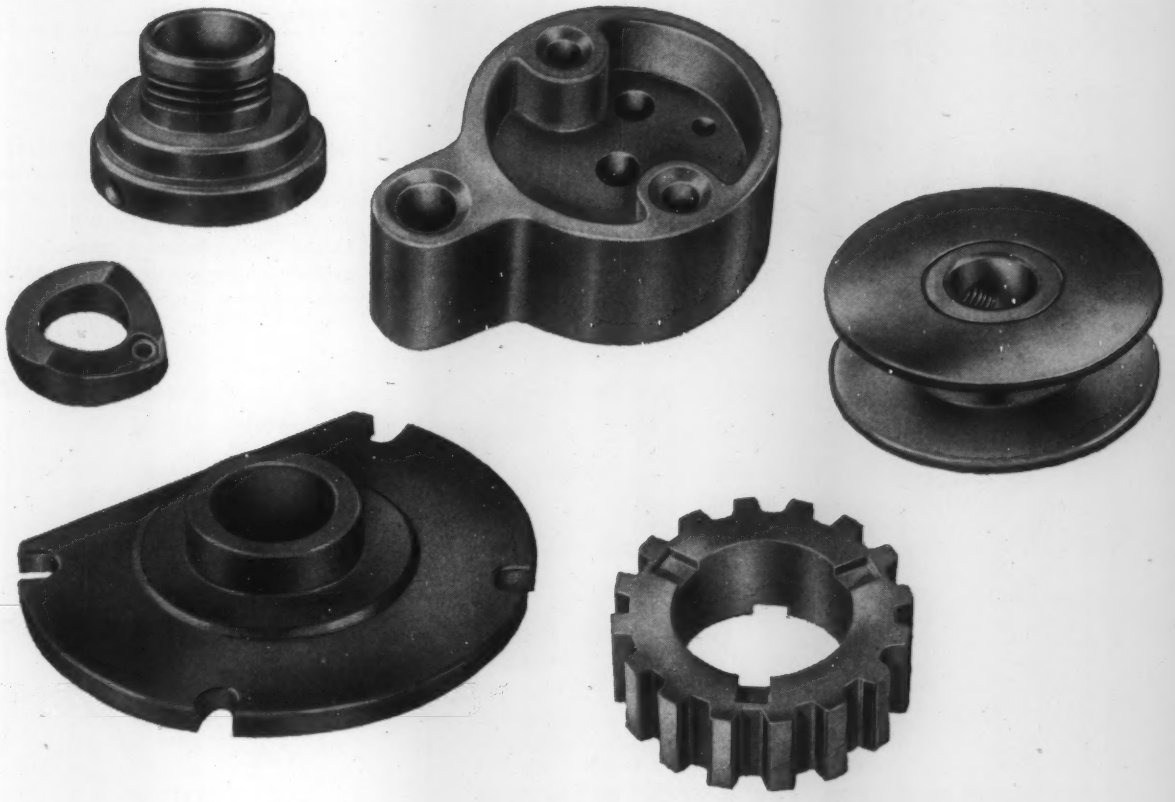
(PRODUCTS OF POWDER METALLURGY)

in the exact form to meet your ...ready to install!

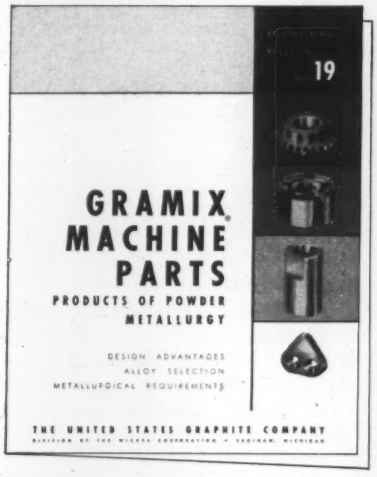
Were you to machine the above parts from bar stock, or were you to finish them from rough castings or forgings, the cost would be considerable, due to their complex shapes. However, these parts—and thousands of others of comparable complexity—are produced economically by the GRAMIX process. GRAMIX parts are die-pressed to the exact shape desired, with tolerances as close as .0005″, then sintered. Further machining is seldom necessary, though we often perform a coining operation to give the part a burnished, work-hardened surface. GRAMIX parts can be impregnated with various high-grade oils to furnish self-lubrication at wear surfaces. Alloys available include an extensive variety of brass, bronze, and ferrous types, and our manufacturing process allows us to accurately control the density of GRAMIX parts, assuring a uniform structure. There is probably a component in your product that could be improved with GRAMIX sintered metal parts . . . Have you given it consideration?

THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



machine parts can be made design requirements . . .



ENGINEERING BULLETIN No. 19

Product engineers specifying materials will find a wealth of design information in this GRAMIX Machine Parts Bulletin. This material is presented in such concise form that questions are quickly and easily answered. A simple chart indicates which alloys—ferrous and non-ferrous—are suitable for different operating requirements. Working sketches show the various design possibilities—radii, helical teeth, dead-end holes, flanges, multiple shoulders—and how they can be utilized to best advantage. Physical properties are presented, and metallography discussed. In all, you'll find Bulletin 19 an ideally simplified guide to a complex subject . . . write now for your copy. 118

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Non-Contaminating!
Self-Lubricating!

—SPECIFY

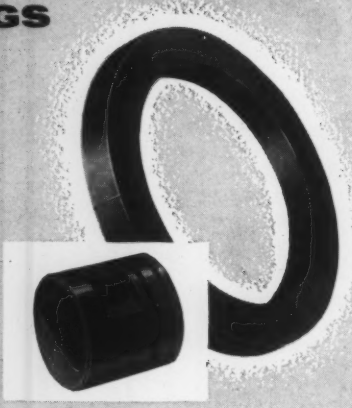
morganite

SELF-LUBRICATING

CARBON PISTON RINGS and ROD PACKINGS

. . . for non-lubricated compressors

Eliminates lubrication problems in compressors where contamination cannot be tolerated. The inherent lubricating property of Morganite, plus ability to polish and glaze compensating surfaces, assure friction minimizing operation. A corrosion resistant film imparted to opposing metal surfaces prevents scoring . . . reduces maintenance and replacement.



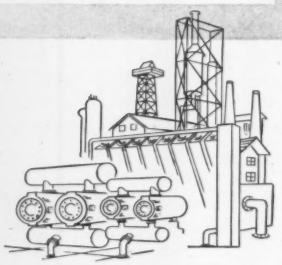
CARBON GLAND RINGS

. . . for high sealing efficiency

For trouble-free operation in turbines, compressors, blowers, fans.

These high efficiency pressure and vacuum seals for steam turbines can be safely mounted with less clearance than metallic rings. Unaffected by axial movement of shaft, accommodate considerable radial shaft displacement with no danger of seizure or loss of efficiency.

Specify Morganite! For sealed mechanisms, inaccessible locations or where contamination is a problem—Morganite Self Lubricating Bearings, Valve Components, Slides, Seal Noses and Pump Vanes are available. Write for complete details and literature, now!



Morganite INCORPORATED

TRADE MARK

3314 48th Avenue
Long Island City 1
New York

. . . FOR OVER HALF A CENTURY

Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

News Roundup

(*Continued from Page* 31)

St., New York 18, N.Y.

Sept. 9-11—

American Institute of Electrical Engineers. Petroleum conference to be held at the Penn-Sheraton Hotel, Philadelphia. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 9-12—

Society of Automotive Engineers Inc. Tractor Meeting and Production Forum to be held at Hotel Schroeder, Milwaukee. Additional information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

Sept. 9-13—

Instrument Society of America. 12th Annual Instrument-Automation Conference and Exhibit to be held in the Public Auditorium, Cleveland. Further information can be obtained from Herbert S. Kindler, Director of Technical Programs, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 17-20—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N.Y.

Sept. 23-24—

Steel Founders' Society of America. Fall Meeting to be held at The Homestead, Hot Springs, Va. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

Sept. 23-25—

American Society of Mechanical Engineers. Fall meeting to be held at Hotel Statler, Hartford, Conn. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 23-25—

Standards Engineers Society. Sixth Annual Meeting to be held at Hotel Commodore, New York. Further information can be obtained from G. H. Kitchen, Bell

Telephone Laboratories Inc., Room 1B-118, Murray Hill, N. J.

Sept. 23-26—

Association of Iron and Steel Engineers. Annual convention to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 24-25—

Sixth Annual Industrial Electronics Symposium to be held at the Morrison Hotel, Chicago. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further information can be obtained from H. L. Garbarino, Armour Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Sept. 30-Oct. 1—

Material Handling Institute Inc. Joint Industry Fall Meetings to be held at The Greenbrier, White Sulphur Springs, W. Va. Additional information is available from institute headquarters, 1 Gateway Center, Pittsburgh 22, Pa.

Oct. 1-5—

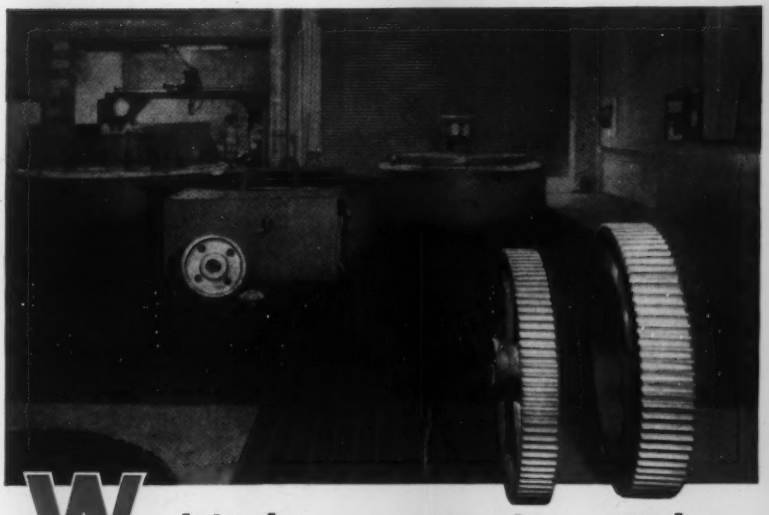
Society of Automotive Engineers Inc. Aeronautic Meeting, Aircraft Production Forum and Aircraft Engineering Display to be held at the Ambassador Hotel, Los Angeles. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

Oct. 3-5—

Porcelain Enamel Institute. 26th Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Additional information is available from PEI headquarters, Associations Bldg., 1145 Nineteenth St. N.W., Washington 6, D. C.

Oct. 7-9—

American Society of Lubrication Engineers — American Society of Mechanical Engineers Joint Lubrication Conference to be held at the Royal York Hotel, Toronto. Further information can be obtained from ASLE headquarters, 84 E.



World's largest Radiant Tube Pit-type Carburizer installed at BRAD FOOTE

...more precise heat treatment for larger gears

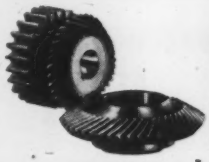
• New heat-treating equipment, including the largest radiant tube pit-type gas carburizing furnace ever built, has recently been installed in the Pittsburgh plant of our subsidiary, Pittsburgh Gear Company. These new additions to BRAD FOOTE's extensive heat-treating equipment provide facilities for the most advanced techniques in deep case carburizing and hardening in controlled atmospheres.

• The new carburizer can handle gears or machine parts up to 6 feet long, 6 feet wide and up to 8500 pounds in weight. In addition to its size, the new equipment has an unusual ability to control carbon penetration, giving extremely precise control of the depth of surface hardening.

• Special heat-treating equipment, like this new carburizer, allows BRAD FOOTE to impart the precise metallurgical characteristics which make for longer wear, shock resistance and freedom from distortion in gears of all sizes and types. And BRAD FOOTE heat-treating is under the supervision of metallurgists with long experience in the special problems of the gear industry.

• Whether you want one gear or ten thousand, BRAD FOOTE's extensive facilities and specialized skills are at your disposal. Send us the specification on your next problem job for quotation. No obligation, of course.

BRAD FOOTE MAKES
Spur • Bevel
Helical • Spiral Bevel
Herringbone
Zerol • Worms
Worm Gears • Reducers
Transmissions



BRAD FOOTE GEAR WORKS, INC.
1308 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • Olympic 2-7700 • TWX: CIC-2856-U

subsidiaries
AMERICAN GEAR & MFG. CO. Phone: Lemont 920 Lemont, Illinois
PITTSBURGH GEAR COMPANY Phone: SPalding 1-4600 Pittsburgh 25, Pennsylvania

Circle 423 on page 19

A

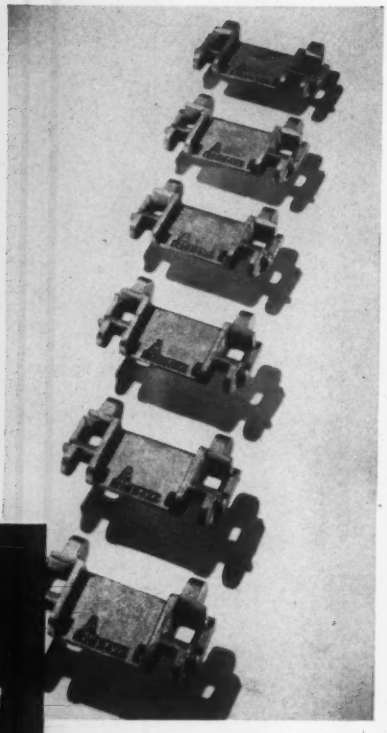
QUARTER MILLION

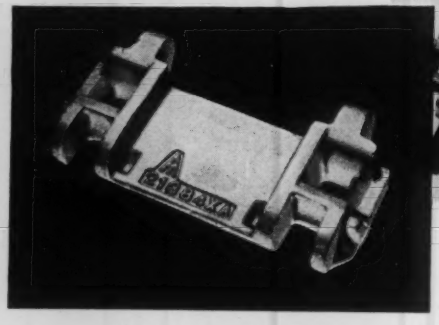
"STEPS"

IN THE

RIGHT

DIRECTION . .





Today's Modern Miner does BETTER with UNITCASTINGS!

Real proof of the continuous high quality of Unitcastings is the fact that more than 99 percent of the total production of 250,000 treads has been accepted!

Continual operation in underground grit and dust subjects mining machinery treads to extreme abuse. Replacement is difficult and expensive, particularly on this section of the equipment, and parts must be made to last!

For over a decade, the abrasion-resistance quality of Unitcast's T-Loy 34 has answered this tread problem—as well as many other special parts for the same equipment.

Take a step in the right direction, too—*you'll do better with Unitcastings!* They're Engineered!

UNITCAST CORPORATION • Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

News Roundup

Randolph St., Chicago 1, Ill.

Oct. 7-9—

National Electronics Conference. Annual meeting and show to be held at the Sherman Hotel, Chicago. Further information can be obtained from American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

Oct. 7-11—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE headquarterters, 33 W. 39th St., New York 18, N. Y.

Oct. 9-11—

Gray Iron Founders' Society Inc. Annual Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, National City —E. Sixth Bldg., Cleveland 14, O.

Oct. 9-11—

Fourth Annual Symposium of High Vacuum Technology to be held at Hotel Somerset, Boston. Sponsor is the Committee on Vacuum Techniques, P. O. Box 1282, Boston 9, Mass.

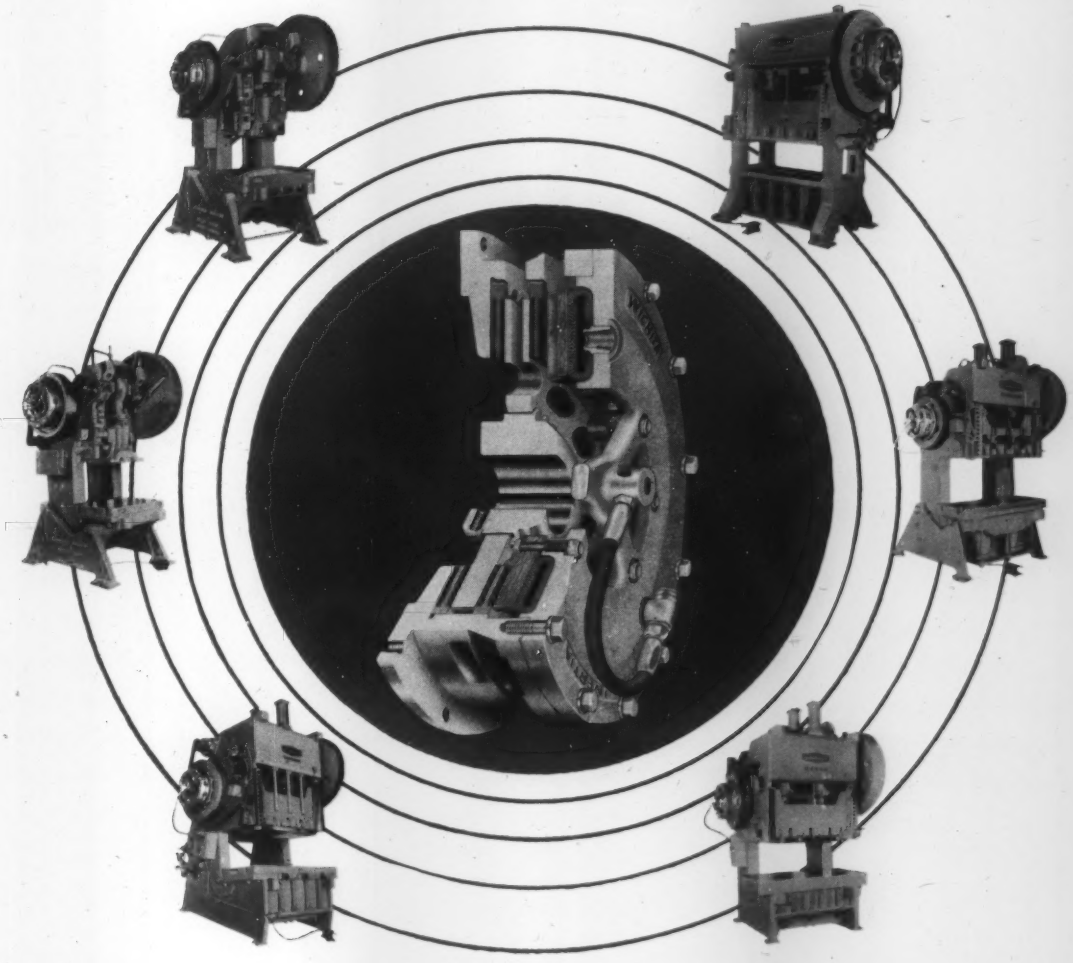
Oct. 14-15—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

"This idea came like a flash in the middle of the night."

Circle 424 on page 19

At Johnson* an air clutch MEANS IT'S A WICHITA CLUTCH



WHEN it calls for an air clutch on a Johnson Press ... the selection is WICHITA. For nearly four years WICHITA CLUTCHES have been standard equipment on all Johnson Presses using air clutches. After checking and testing other types, Johnson engineers specified WICHITA CLUTCHES because they offered efficient clutching operation. Important WICHITA CLUTCH features include: (1) Extremely fast engagement and disengagement; (2) positive air cooling; (3) No adjustments required; (4) No lubrication required; (5) Complete freedom from effects of centrifugal force; (6) Quicker action with less power consumption; (7) Less consumption of air.

ASK A WICHITA ENGINEER FOR FULL FACTS on how WICHITA CLUTCHES can best serve your needs on new equipment or conversions.

*Johnson Machine & Press Corp.
Elkhart, Indiana

WICHITA ENGINEERS

Brehm-Lahner, Inc., Detroit, Mich.
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co. (Main Office), Avon, Conn.
Smith-Keser & Co., Philadelphia 44, Pa.
Smith-Keser & Co., New York, New York
Frank W. Yarline Co., Chicago, Ill.
Larry W. McDowell, Long Beach, Calif.
Andrew T. Lobel, Denver, Colorado

Robert R. King Co., Cleveland, Ohio
Dominion Power Press Equipment Ltd., Burlington, Ontario, Canada
Allied Transmission Equipment Co., Kansas City 8, Missouri
R. E. Kunz, Seattle, Wash.
W. G. Ballantyne & Co., Portland, Ore.
Norman Williams, Houston, Texas

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

Circle 425 on page 19

Here at last

FULL 42-INCH PRINTMAKING IN A CONVENIENT Table Model

Now, TABLE MODEL convenience, LOW COST and FULL WIDTH are combined in *one* whiteprinter—the new Ozalid Streamliner 200!

Now, anyone can turn out sparkling whiteprints in seconds—up to 42 inches in width! In the small office, the new Streamliner 200 gives you prints whenever you need them. For the large firm, it handles "rush work"... saves costly interruptions of volume printmaking . . . *stands by* when other machines are "down" for service.

Compact in design, Streamliner 200 stands just 22″ high . . . 38″ deep, with feedboard. Prints stack automatically. Controls are simple, easy to operate. Stand, shown above, is optional.

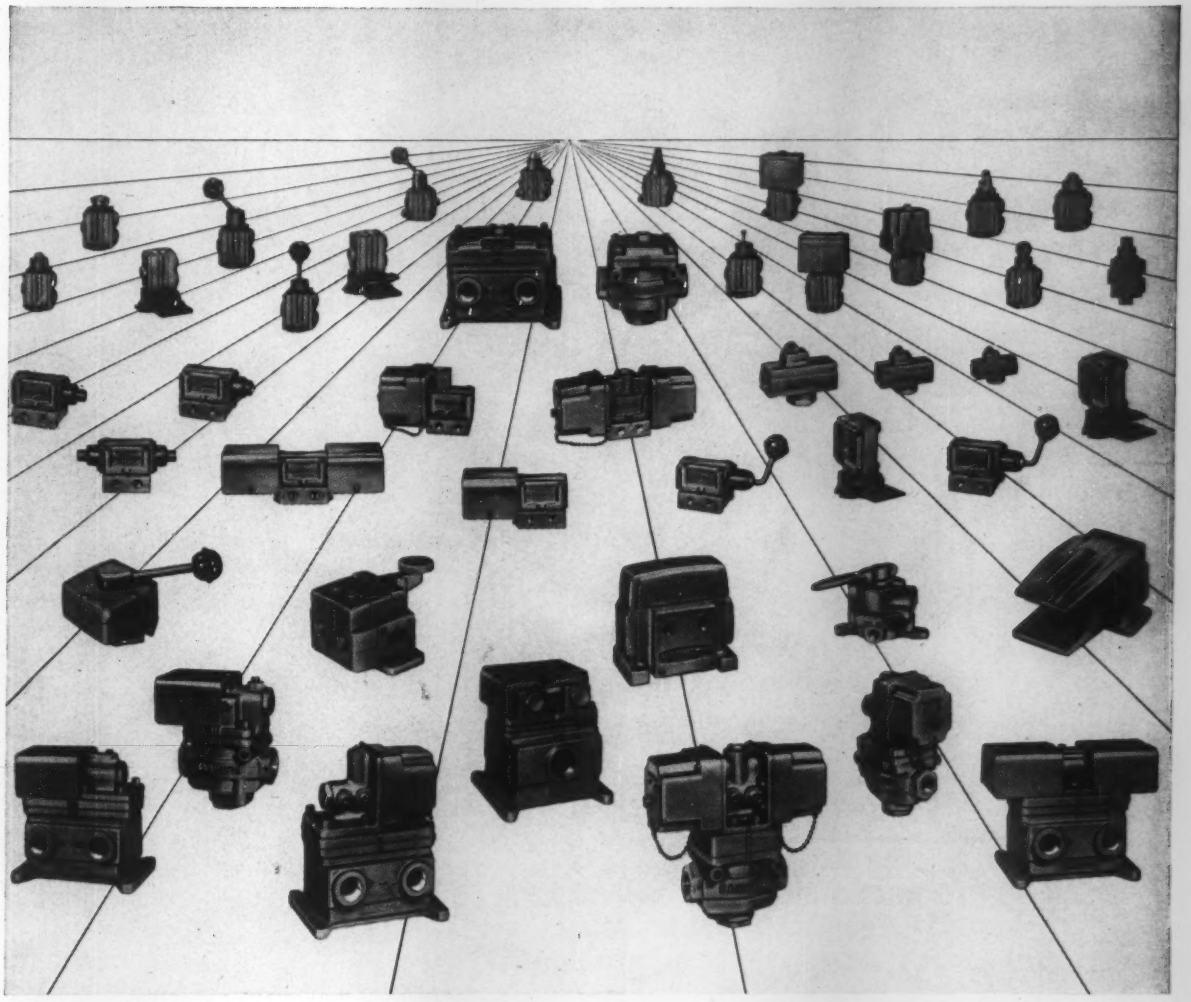
Why not test-run your own tracings through the Streamliner 200? Call your local Ozalid representative or write: Ozalid, Department GG-7, Johnson City, New York.

A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

OZALID®

First name in whiteprinting

Circle 426 on page 19



These valves like tough jobs

Discriminating engineers are finding that out. More and more of them are specifying Hannifin valves for every kind of directional air control—including the really tough jobs.

There are plenty of reasons why: Inspired simplicity of design. Fewer parts—and *those* easily and quickly replaceable. Ability to serve a wide range of applications with fewer valve models. And—above all—fast, smooth operation.

Your Hannifin man will gladly give you the whole story. We'll tell you where to get in touch with him—after you examine the big Hannifin catalog.

AIR CONTROL

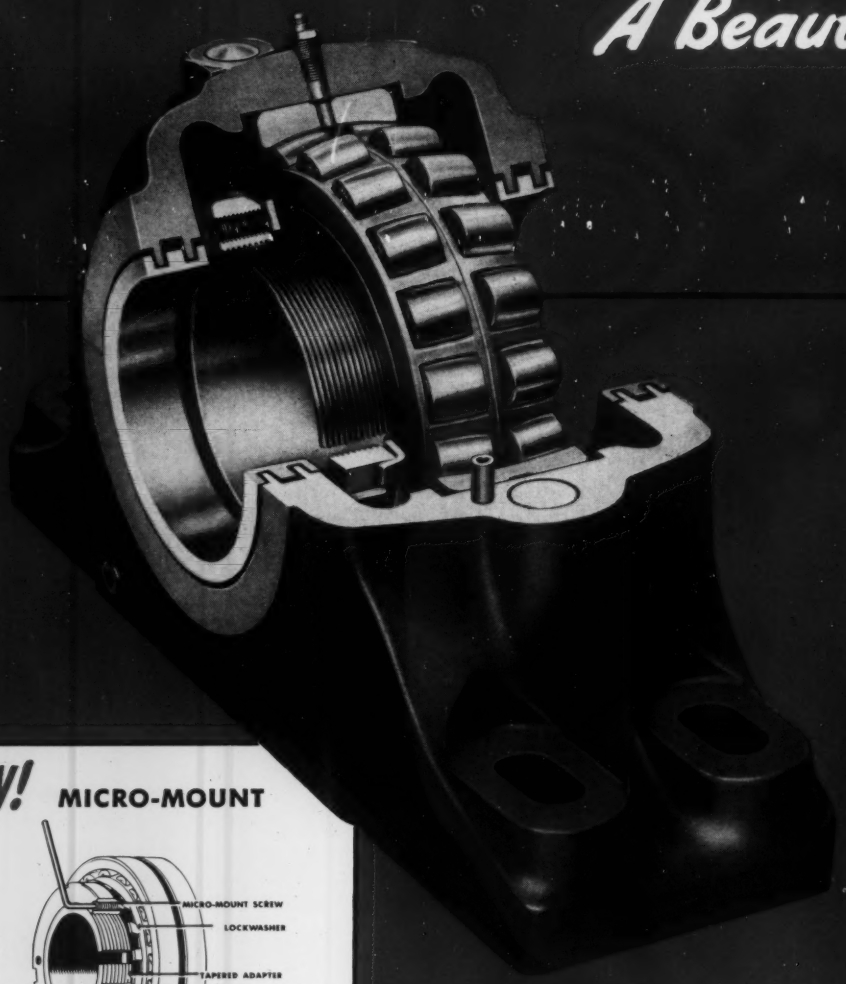
HANNIFIN

VALVES

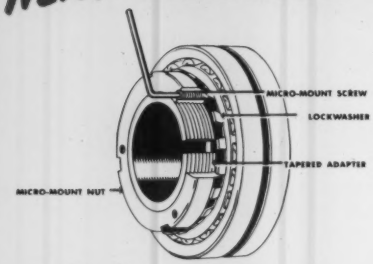
For this complete catalog **showing all the Hannifin directional air control valves, write to Hannifin Corporation, 515 South Wolf Road, Des Plaines, Illinois.**

Circle 427 on page 19

A Beautiful



NEW! MICRO-MOUNT



Fast and accurate mounting is made possible by the new Dodge Micro-Mount. The Adapter is snugged up with the Micro-Mount Nut. Mounting is completed by turning the Micro-Mount Screws against the Lockwasher until bearing, adapter and shaft form an integral unit.

Now — a spherical roller bearing pillow block has been added to "America's most complete line of mounted bearings."

This new Dodge product possesses all the fine characteristics of the spherical type, plus the precision, dependability and refinements you would expect from the nation's leading supplier of mounted bearings.

Rugged housing of close-grained semisteel, in compact modern design, withstands shock loads. The new Micro-Mount Adapter seats Spher-Align solidly on shaft, *with amazing ease and speed.* A new feature of bearing design allows lubricant to enter at center of bearing and move outwardly along all bearing surfaces. Convenient drain plugs permit use of either grease or oil and provide for easy flushing. Triple seals retain lubricant.

Standardized dimensions make Spher-Align interchangeable with all other similar units. Available in expansion and non-expansion types. In stock for 2 7/16" to 8" shafts. Call your Dodge Transmissioneer — or write us.

DODGE MANUFACTURING CORPORATION • 3300 UNION ST., MISHAWAKA, INDIANA

New Bearing by Dodge—

Spher-Align

ANNOUNCING AMERICA'S NEWEST SPHERICAL ROLLER BEARING PILLOW BLOCK ...A RUGGED BEARING IN ATTRACTIVE MODERN DESIGN...INHERENTLY SELF-ALIGNING...EASY TO INSTALL...EASY TO MAINTAIN...AND FEATURING THE UNIQUE MICRO-MOUNT ADAPTER

AMERICA'S MOST COMPLETE LINE OF MOUNTED BEARINGS

DODGE-TIMKEN
Tapered Roller

SPHER-ALIGN
Spherical Roller

SC, SCM, SL
Ball

SLEEVOIL
Precision Ring Oiling

BRONZOIL
Capillary Oiling

BABBITTED
Solid and Split

PILLOW BLOCKS • HANGER BEARINGS
FLANGE BEARINGS • UNIT MOUNTS • TAKE-UPS

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in the yellow pages of your telephone directory — or write us.

Circle 428 on page 19

only SOUTHCO® drive rivets offer all these benefits!

Rivet and Mfg. Patented.

A HAMMER IS THE ONLY TOOL

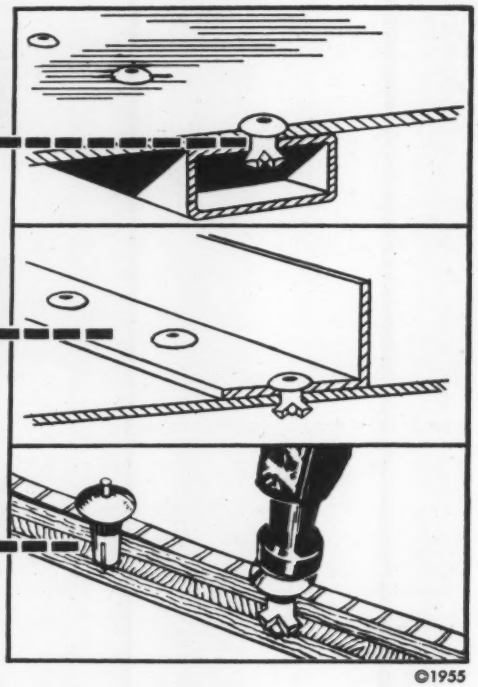
DRIVE LIKE NAILS

AUTOMATIC "PULL-UP" ACTION FORCES PARTS TOGETHER

FOR BLIND APPLICATIONS

FOR ACCESS APPLICATIONS

FOR METAL-TO-WOOD APPLICATIONS



Note

No special tools to buy or maintain, no bucking up, no finishing, no noise, no material waste.

Just hit the pin, the rivet's in . . . that's all.

On your production line, where can savings be made with Southco Drive Rivets? Write for complete data. Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SPEED ASSEMBLY . . . CUT COSTS

©1955

SOUTHCO® FASTENERS

LION

Circle 429 on page 19

What every designer should know about

FACE GEARS for Angular Drives

DESIGN OF "ON CENTER" FACE GEARS
DESIGN OF "OFF-CENTER" FACE GEARS
Published by:
THE FELLOWS GEAR SHAPER COMPANY
Springfield, Vermont, U.S.A.

FACE GEARS have distinct advantages which the designer should know. They can be spur or helical, "on-center" or "off-center." The mating members are pinions. Both are generated on Fellows Gear Shapers by cutters having involute teeth.

Utilization of face gears results in a simple, compact design that can be economically manufactured and assembled.

Consider all these advantages:

- quality cutting at low cost
- easier and lower cost assembly
- no appreciable thrust
- pairing for reversal of direction
- tooth bearing not affected by axial displacement of pinion

GET ALL THE FACTS:

Information on the design and cutting of Face Gears is free for the asking. Just write to:

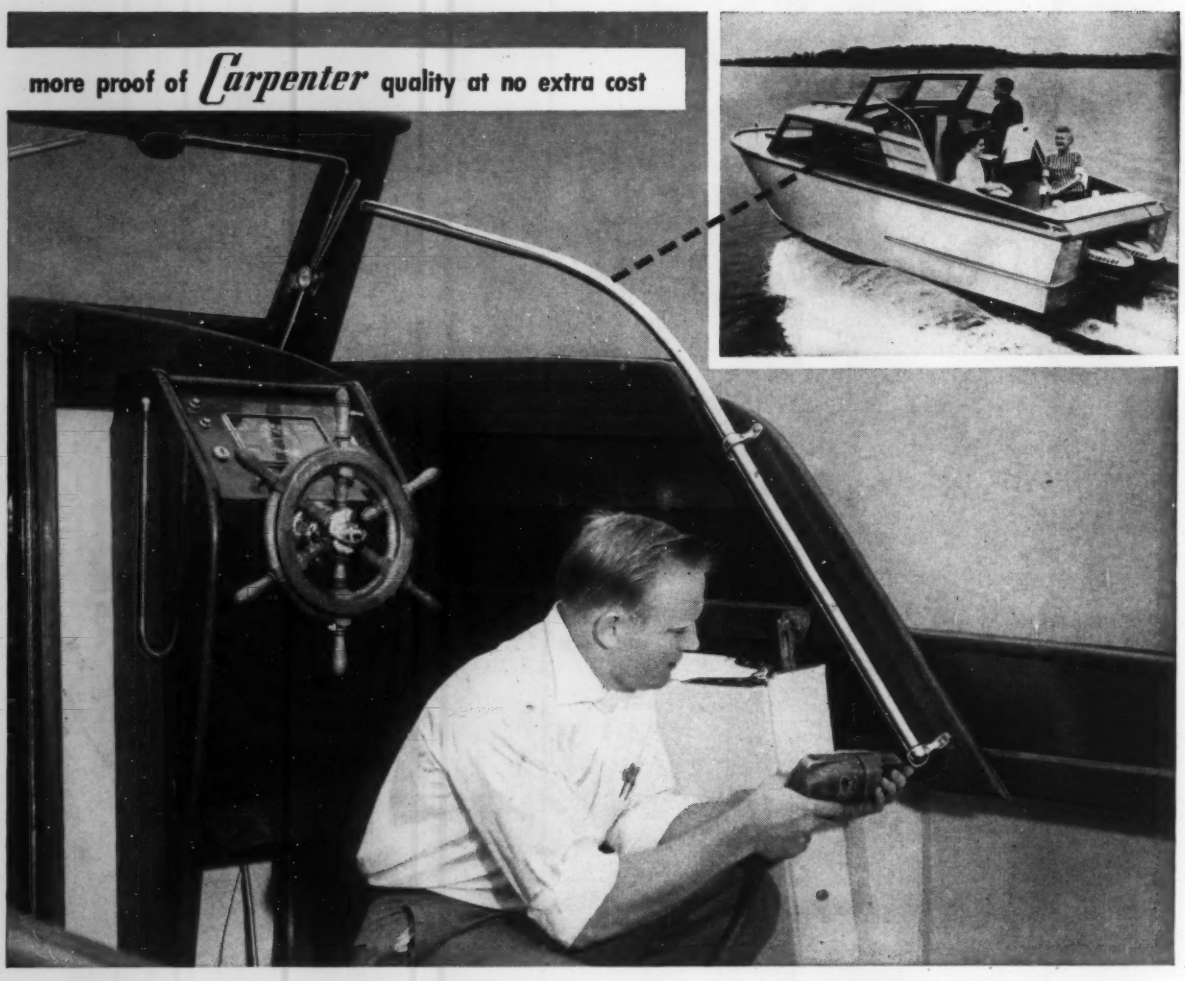
THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont

Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*

Circle 430 on page 19

more proof of *Carpenter* quality at no extra cost



Costs cut 25% on boat handrails by switching to *Carpenter* Stainless Tubing

● Note the reasons why a 1957 line of 22-foot pleasure cruisers features gleaming stainless steel handrails:

By changing to Type 302 Carpenter Stainless Tubing, time and costs of making the handrails has been reduced 25%. Better bendability, improved appearance and no plating to peel in marine atmosphere are other important advantages gained. The tubing is 1″ O.D. with 18-gauge wall thickness, and 180-grit polished finish, in 22-ft. lengths.

The boat builder reports that Carpenter Stainless Tubing bends around a special 30-in. radius jig with less spring-back and shows no kinks or marks from bending. For maximum attractiveness, it is polished on a 240-grit and buffed.

Get this cost-saving quality and workability of stainless tubing for your products or equipment by calling your nearby Carpenter Distributor. He's at your service on over 30 different stainless and specialty analyses in a wide range of sizes, gauges, shapes and finishes . . . for pressure, mechanical, structural and sanitary services.

MEMBER

The Carpenter Steel Company
Alloy Tube Division, Union, N. J.

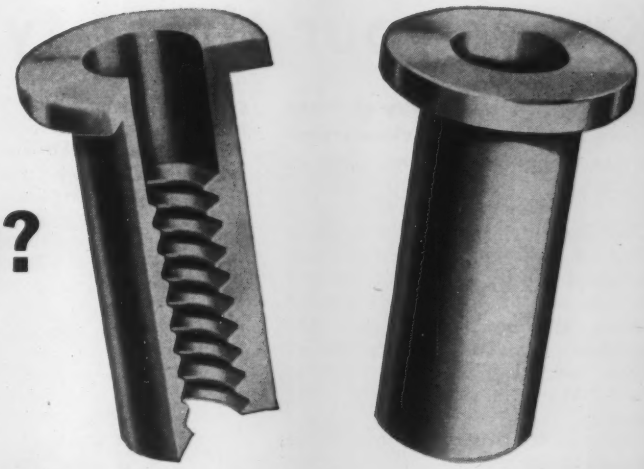
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

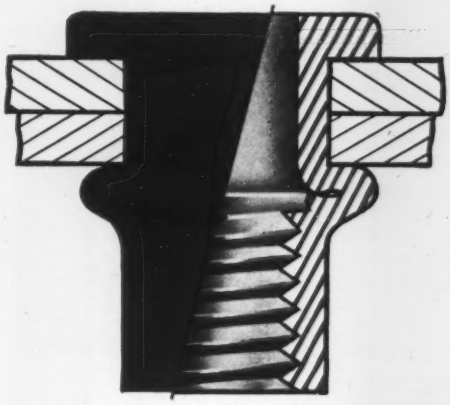
more than corrosion resistance

Stainless Tubing & Pipe

What are they?



B. F. Goodrich Rivnuts®–the only one-piece blind fasteners with threads



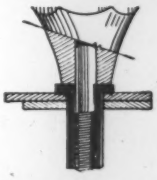
If you have a fastening problem, solve it the easy way—with B. F. Goodrich Rivnuts. One man can install Rivnuts blind from one side of the work. It takes only a few seconds—speeds assembly and cuts costs as much as 50-90% depending upon the applications.

Rivnuts are stronger, too, because they provide at least 6 clean threads, even in thin sheet metal. By eliminating welding, tapping and cleaning, Rivnuts eliminate costly steps in production and straighten out assembly lines.

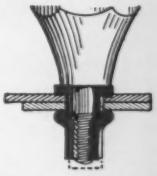
Rivnuts come in a variety of types and sizes and materials to solve your specific fastening problem, in sheet metal, wood, plastic. For complete information, send for the FREE RIVNUT DEMONSTRATOR. It shows with motion how Rivnuts fasten *to* and *with*. B.F.Goodrich Rivnuts, Dept. MD-77, Akron, Ohio.

Rivnuts® provide at least 6 clean threads in one simple operation

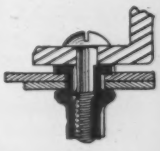
1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work — tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.



4 After upset, Rivnut threads are still clean and intact ready for screw attachment.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

Circle 432 on page 19

(Advertisement)

Know your timer types...

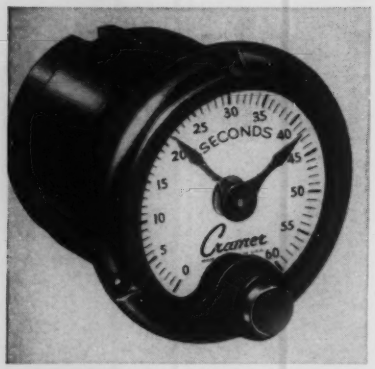
Grouping the multiplicity of timer types into four broad classes simplifies equipment designer's job:

INTERVAL TIMERS

The first—and simplest—group is that of the interval timers. These consist basically of a motor, an arm or cam, and a switch. To operate the timer, the user simply sets the mechanism manually to the desired time interval. This action transfers switch contacts that start the timer motor.

The motor drives the timer mechanism to the end of the timing cycle. At this point the switch returns to its original position and the motor shuts off.

A variety of dials, knobs, push-button start, automatic reset features, special housings and additional load switches may be used, but the basic operation is the same. Interval timers are used in applications that require frequent changes in setting—like photographic exposure timing.



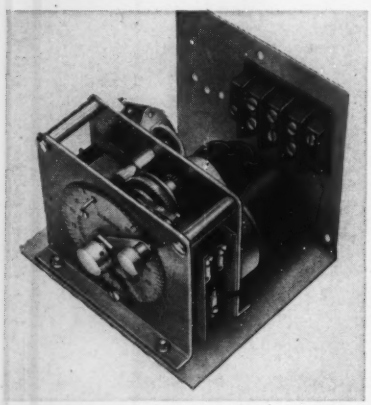
INTERVAL TIMER of advanced design, the new Cramer Type 241 features large easy-to-read dial, pushbutton start, automatic and immediate reset and repeat accuracy of ± ¼ of 1% of full scale. Bulletin PB-241.

TIME DELAY RELAYS

The time delay relay represents the second large group of timing devices. These units provide accurately timed delays between the closing of an external remote switch and the transfer of a load switch. At the end of each cycle, the motor shuts off automatically, and the standard device remains in this "timed out" condition until the clutch is released allowing the timer to reset. Other variations reset automatically at the end of a cycle. Models are available to either reset on power failure or suspend operation until the circuit is restored.

Special housings, additional switches, various clutching mechanisms, and a wide selection of wiring arrangements make the time delay relay an extremely versatile device.

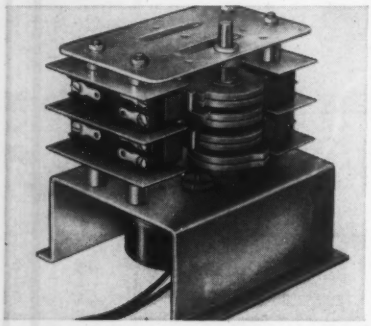
A typical application is for regulating processes such as heat treating where the timer controls the amount of time required to produce the desired change in the metal.



TIME DELAY RELAYS—like the Cramer Type 440A above—are rugged, dependable and accurate devices to control from 1 to 5 load circuits. For flush, surface or panel mounting. Bulletins PB-310 and PB-311.

CYCLING TIMERS

In the third category are found the cycling timers. Fundamentally these units are made up of the driving motor, a cam (or arm) which is revolved continually by the motor, and a switch operated by the cam. The cycling timer produces switch transfer repeatedly, according to the cam cuts, as long as the motor runs.

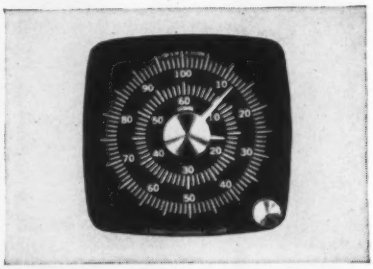


CYCLING TIMERS—like this Cramer Type 520 come in 1 to 8 poles. Normally factory preset for highest accuracy. Operating speeds 1 rev./6 sec. to 1 rev./day. Bulletin PB-510A.

Variations of the cycle timer include changing the motor speed, cutting cams in an almost infinite number of combinations, and adding switches. The cam setting may be fixed or adjustable. Special housings are available. Cycle timers are used to control a program or sequence of events as in a signaling system.

TIME TOTALIZERS

Time totalizers, or elapsed time indicators, range in complexity from a simple motor-driven counter to the precision time totalizer used in scientific research. The former, usually used as a running time meter, counts discrete time *units* from tenths of a second to hours. The more elaborate time totalizer is actually an electrical stop clock capable of measuring time intervals to an accuracy of ± 0.01 second. Running time meters are used to record the operating or down time of industrial machines. They are offered in many models—with or without reset, in portable or die-cast enclosures, etc. Time totalizers are commonly applied in test equipment for industrial and military laboratories.



NEW TIME TOTALIZER of laboratory quality. This new Cramer Type 691 features instantaneous electrical reset (within .1 second). It is human-engineered by Raymond Loewy for fast exact readings, accuracy to ± .01 second. Reset can be either by local push button or controlled remotely. Bulletin PB-691.

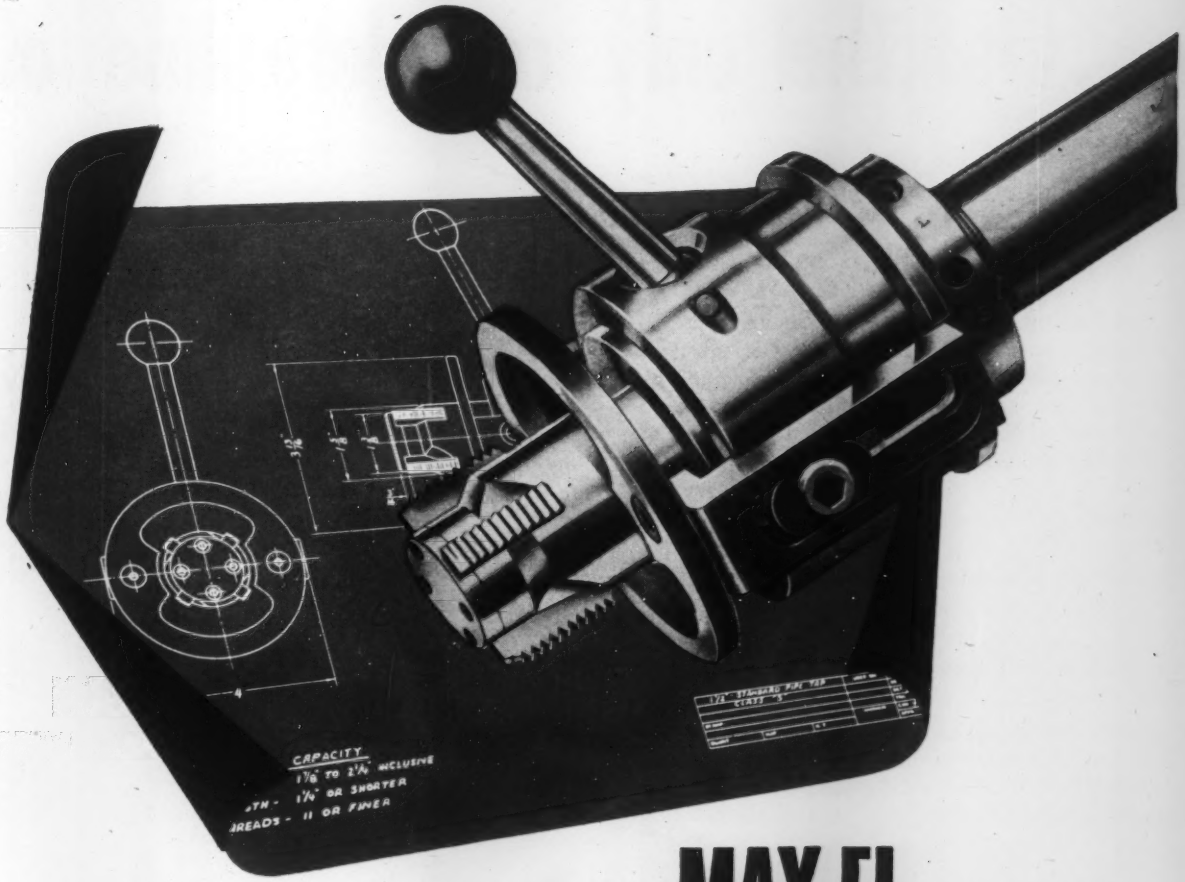
7.1R

LEARN MORE about these four basic timer types from Cramer's complete line. Just ask us to send you our bulletins on the types that interest you. Nearly 100 varieties are *stocked* for immediate shipment. Cramer Controls Corporation, Box 6, Centerbrook, Connecticut. (Formerly R.W. Cramer Co.)

TALK IT OVER WITH

CRAMER CONTROLS
CORPORATION

Circle 433 on page 19



Universal collapsing tap parts of **MAX-EL** alloy steel finish machined after full heat treatment

Considerable machining is required in the manufacture of parts for these taps. That's why Crucible MAX-EL® 3½ free machining alloy steel was chosen by the Geometric Tool Company, Division of Greenfield Tap and Die Corporation. For with MAX-EL you can rough machine, *then* heat treat even intricate parts before final machining *with no danger of distortion of the steel.*

But the best way to check the advantages of MAX-EL is to try it in your own shop. Like many other users you'll appreciate its superior machinability, freedom from distortion, deep hardenability characteristics, uniformity and quality. And you'll like the longer tool life you get by using MAX-EL.

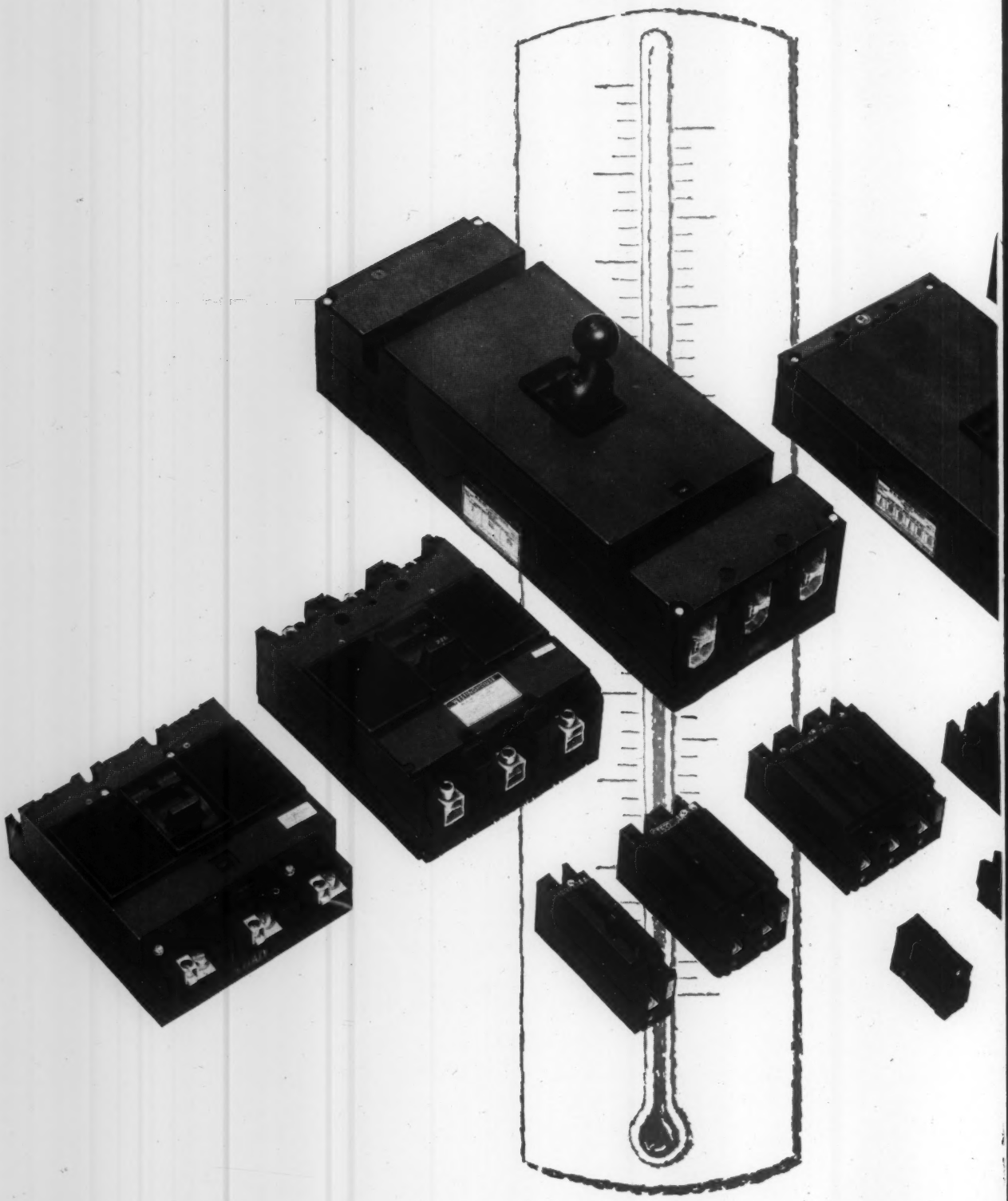
For complete data . . . and *quick delivery* of MAX-EL alloy steels, from local warehouse stocks, call *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Circle 434 on page 19

The only complete line of



ambient compensated breakers...

Westinghouse

Whenever circuit breakers are subject to wide ambient temperature variations to which associated conductors are not exposed, an ambient compensated type of breaker should be specified. This provides added insurance against current interruptions due to false high-temperature influences. The net effect is to prevent the breaker from unnecessarily derating the conductors.

Typical of the conditions under which ambient compensation may be required are . . .

In panelboards or load centers where a large number of closely grouped breakers create high temperatures.

Proximity of breaker installation to other equipment causing ambient variations to which the conductors are not exposed.

Westinghouse has the only complete line of circuit breakers to meet every requirement. (1) "Compensated for enclosure ambient," standard in Quicklag® breakers, (2) "Noncompensated for ambient re-rating," standard in Types E through M, (3) "Ambient compensated," by specification in Types E through M.

The engineering "know-how" which goes into the development of this reliable protective equipment is available to aid you in selection of the right type of breaker for your particular circuit conditions. Ask for Westinghouse Bulletin 7221 detailing technical information on the choice of circuit breakers.

J-30277

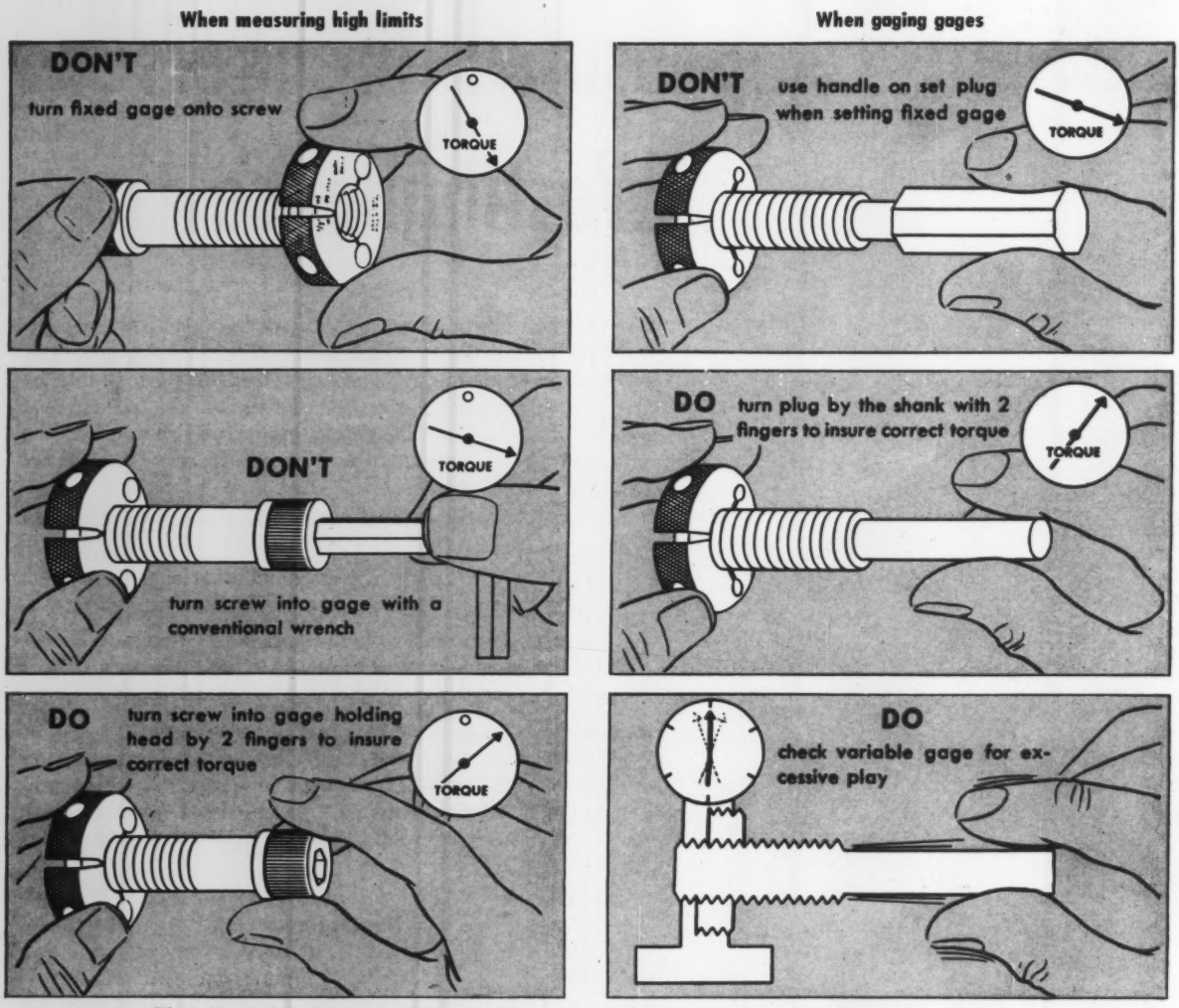
Get proper breaker protection under all ambient conditions.

YOU CAN BE SURE...IF IT'S

Westinghouse

Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pennsylvania

Circle 435 on page 19



These illustrations from new SPS booklet show some of the do's and don'ts of gaging precision threads.

3A threads: what they are; how to gage them — new SPS booklet tells all

Threads made to Class 3A fit are the most precise in general use in industry. But you do not always get the 3A precision you specify. Because of many different gaging techniques that yield varying results, screws with threads well outside the Class 3A tolerance limits often pass inspection.

SPS has prepared a new booklet on this subject. It explains clearly what Class 3A threads are and the pros and cons involved in the widely varying gaging techniques in use today. It reviews the gaging of high and low limits of 3A threads, sampling techniques, and even the methods of gaging gages.

All standard UNBRAKO socket screw products fall within specified tolerance limits *no matter what method is used to gage them.* Leading industrial distributors carry complete stocks. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

Form 2239, "Class 3A Threads: what they are; how to gage them." 16 pages, with many illustrations. Write for free copy today.

STANDARD PRESSED STEEL CO.

UNBRAKO® SOCKET SCREW DIVISION SPS

JENKINTOWN PENNSYLVANIA

(Advertisement)

Design data on adhesives

Armstrong
ADHESIVES • COATINGS • SEALERS

NUMBER THREE

Strengthening a metal-to-metal joint

Four basic rules must be kept in mind in order to strengthen any joints to be adhesive-bonded.

These rules are:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which adhesive is weakest.

Here's how two of these rules were applied in improving the bond of a metal label to a fire extinguisher.

A

This label was designed for fastening with rivets. The label is flat, has embossed letters, and has holes drilled for riveting. Contact is very poor because of the embossing, resulting in low strength and low resistance to peel or cleavage stresses on the edge of the joint.

B

Remedy

This label was designed for adhesive bonding. The label is pre-curved and has a smooth back for 100% contact. This type of bond will prevent failure when a stress is applied at the edge of the bond with a fingernail or, for example, with some sharp instrument.

1. Bonded area has been made as large as possible.
2. Maximum proportion of bonded area now contributes to strength.

If you have a design problem involving adhesive bonding, we may be able to suggest a practical, economical solution based on our 36 years of experience in making and using adhesives, coatings, and sealers. Send details of your problem to Armstrong Cork Company, Industrial Div., 8007 Dean St., Lancaster, Pa.

Factors in adhesive bonding

Most assembly requirements for adhesive-bonded materials include factors of time, heat, and pressure. These vary with the adhesive used and also with the materials bonded.

Time

Two time factors are involved, open time and setting time. Open time is the period of time that can or must elapse between coating the parts and joining them. Some adhesives permit little open time; others must be kept open for intervals ranging from five minutes to twenty-four hours.

Setting time is the period that must elapse before an adhesive bond attains its full strength. Here again the interval may be measured in seconds or weeks, depending upon the adhesive, the materials bonded, and the curing procedure, if any.

Heat

Heat is required in varying degrees in many adhesive applications. Whether one or both surfaces are coated, forced drying of the adhesive film by heating and circulating air is usually desirable and often necessary. The use of heat speeds drying, makes drying independent of weather conditions, and prevents water condensation on the adhesive film.

PHOTO COURTESY CHEVROLET-DETROIT GEAR AND AXLE DIV., GENERAL MOTORS CORP.

ADHESIVE-COATED brake shoes and brake bands are assembled on a conveyor line. The brake band is first placed inside a pressure band and against the brake shoe. Pressure springs are then positioned. The assembly is then baked.

Controlled drying also makes it easier to begin assembly when the adhesive film has the right amount of tack, this being the point at which the best over-all bond can be made. Under some conditions, it may be more practical to dry the adhesive film completely and later reactivate it with heat or a solvent.

Special Factors

Thermosetting adhesives, which set by a chemical change in the presence of heat and/or a curing agent, require special assembly techniques. Adhesives of this type are most always used in critical applications where the possibility of bond failure cannot be tolerated—as in the bonding of clutch facings to steel plates. Since such bonds cannot be tested except by destruction, they must be made with extra care and control.

Curing

Some thermosetting adhesives must be cured by chemical reaction at room temperature, the bonded parts remaining clamped for a relatively long period of time. Oven heating of assemblies is quite common. Ovens may be heated by gas, oil, electric, or by infrared units. Forced circulation is required by oven heating in order to insure uniform temperature. The fastest curing time is accomplished by dielectric heat, which cures some heat-set adhesives in a few seconds.

Thermosetting adhesives may be cured at temperatures from 75° to 550° F., depending on the specific type. In general, the higher the temperature, the faster the cure. By controlling temperature, the bonding operation can be speeded or slowed to match the pace of almost any assembly line. Parts bonded with thermosetting adhesives usually can be taken from the presses while still hot.

For detailed information on bonding thermosetting adhesives, see the Armstrong Data Sheet, "Thermosetting Adhesives." It is available upon request. Write for your copy today.

Circle 437 on page 19

100 ENGINEERS AVAILABLE

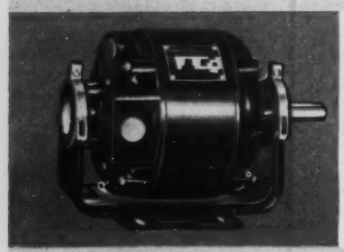
Yes, 100 engineers are ready to go to work for you *right now*. They're Emerson-Electric's *motor specialists*...available to help you in the development of your product—from idea through production.

Every Emerson-Electric motor is custom-engineered to suit your specific needs—*designed* for you, *produced* for you and *priced* for you. It is no longer necessary to design your product around a *standard* motor. Emerson-Electric engineers will help you get the product you want with a motor that exactly suits your purpose... a custom-engineered motor.

Call, wire or write Dept. M-62 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

Engineer

opportunity for mechanical engineers ...a's larger manufacturing firms lo...



Every Emerson-Electric motor is custom-engineered to meet your *exact* requirements.

EMERSON-ELECTRIC

of St. Louis

Since 1890

USING

DU PONT ELASTOMERS

neoprene · Hypalon®

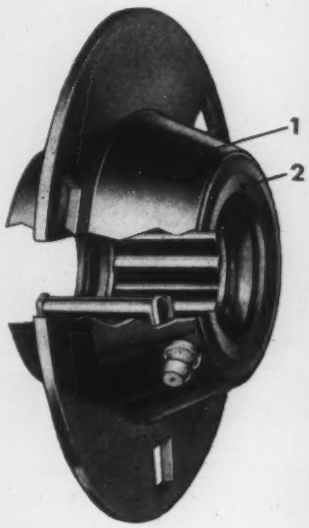
in design

Bearing gives smoother performance, longer life because of neoprene housing and shaft seal

Convertible top coated with HYPALON resists sunlight, weathering, discoloration, cracking

When one large automotive manufacturer wanted a convertible top for new models that would give longer wear, HYPALON was specified as the coating over the canvas body. This newest Du Pont synthetic rubber was chosen because it will not crack or harden under prolonged exposure to weather, and is exceptionally resistant to the effects of sunlight. HYPALON can also be compounded in a wide range of stable colors . . . important as a styling consideration in the competitive automotive industry.

HYPALON offers almost unlimited industrial design possibilities. It is particularly adapted to applications where exceptional ozone resistance and resistance to oxidizing chemicals are important. HYPALON also shows unusual resistance to hardening at elevated temperatures (250°-350° F.). For full information on the useful properties of HYPALON for design, just mail coupon below.



1. Neoprene housing permits shaft alignment changes.
2. Neoprene seal retains lubricant, seals out dirt.

Flexible neoprene housing on roller bearing adapts to instant changes in shaft alignment

This new cartridge type roller bearing, introduced by the Rollway Bearing Company of Syracuse, N. Y., is designed for farm and industrial materials handling equipment. It is made in shaft sizes from 1/2 to 1 7/16 inches. The bearing's flexible neoprene housing adjusts to shaft alignment changes caused by vehicle movement, or shifts in load distribution on pulleys attached to the shaft. It permits misalignment between shaft and bolting flange of at least one degree. This adds considerably to bearing life and cuts fatigue on walls or panels to which the flange is mounted.

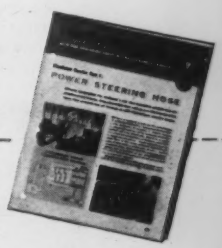
Rollway specified neoprene for the housing and shaft seal because it *keeps* its flexibility despite hard wear and extremes of temperature and humidity. Neoprene was also chosen for its outstanding resistance to oil and grease and the abrasion of dirt and grit. Regular bearing lubrication has no effect on the neoprene seal.

It's this *balanced combination* of properties that makes neoprene so useful for applications where severe service conditions would ruin ordinary rubber or less resilient materials. Neoprene resists acids, oil and grease, abrasion, sunlight and weathering. Mail coupon below for details on how neoprene's many useful properties have been designed into many industrial products, and how they can work for you.

DU PONT
REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



☐ I am particularly interested in _____

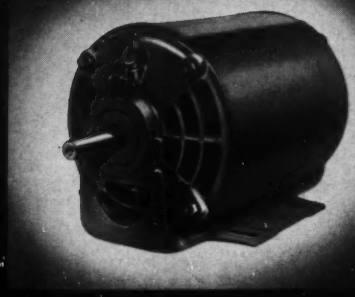
☐ Please add my name to the mailing list for your free publication, the ELASTOMERS NOTEBOOK.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-7
Wilmington 98, Delaware

Name _____
Firm _____
Address _____
City _____ State _____

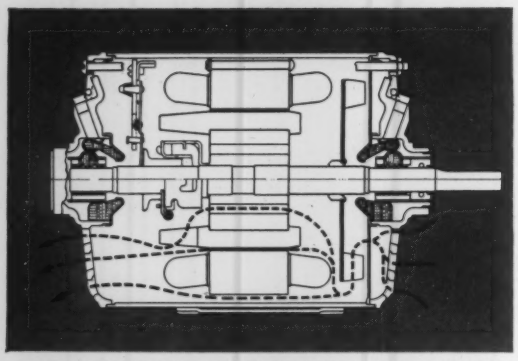
Circle 439 on page 19

DESIGN ENGINEERS!



This compact, cool-running fhp motor saves space and weight... mounts at any angle

the WAGNER "48"



OUTSTANDINGLY EFFICIENT COOLING SYSTEM

Schematic drawing shows how a large volume of air is directed through the motor to effectively reduce temperatures. Large blower at right draws air in through drip-proof openings in back endplate, forces it around back coil extension—through rotor vent holes—air gap—and through passages between stator core and frame. Cast blower at left circulates air around coil extension and drives it out the motor through front endplate openings.

Savings in space and weight are among the many advantages of using Wagner "48" capacitor-start or split-phase motors in your equipment. These motors come in the standard 48 frame sizes and weigh from 3 to 8 pounds less than the previous models in the same hp ratings.

Because no parts of the motor mechanism are housed in the endplates, it is possible to materially reduce their depth. An effective lubrication system assures positive protective lubrication for the bearings in any position. You can mount these motors at the angle best suited to your equipment.

The capacitor-start, Type RK "48" comes in 1/6 or 1/4 hp ratings, and the split-phase, Type RB "48" in 1/6, 1/4 or 1/3 hp. Both types are available with resilient bases or with rigid bases that are welded to the steel motor frames for ruggedness and strength. You can get these motors from leading motor distributors in your community and from Wagner sales offices in 32 principal cities. Check your telephone directory for the supplier nearest you. Write for your file copy of NEW Bulletin MU-217 on the Wagner "48".

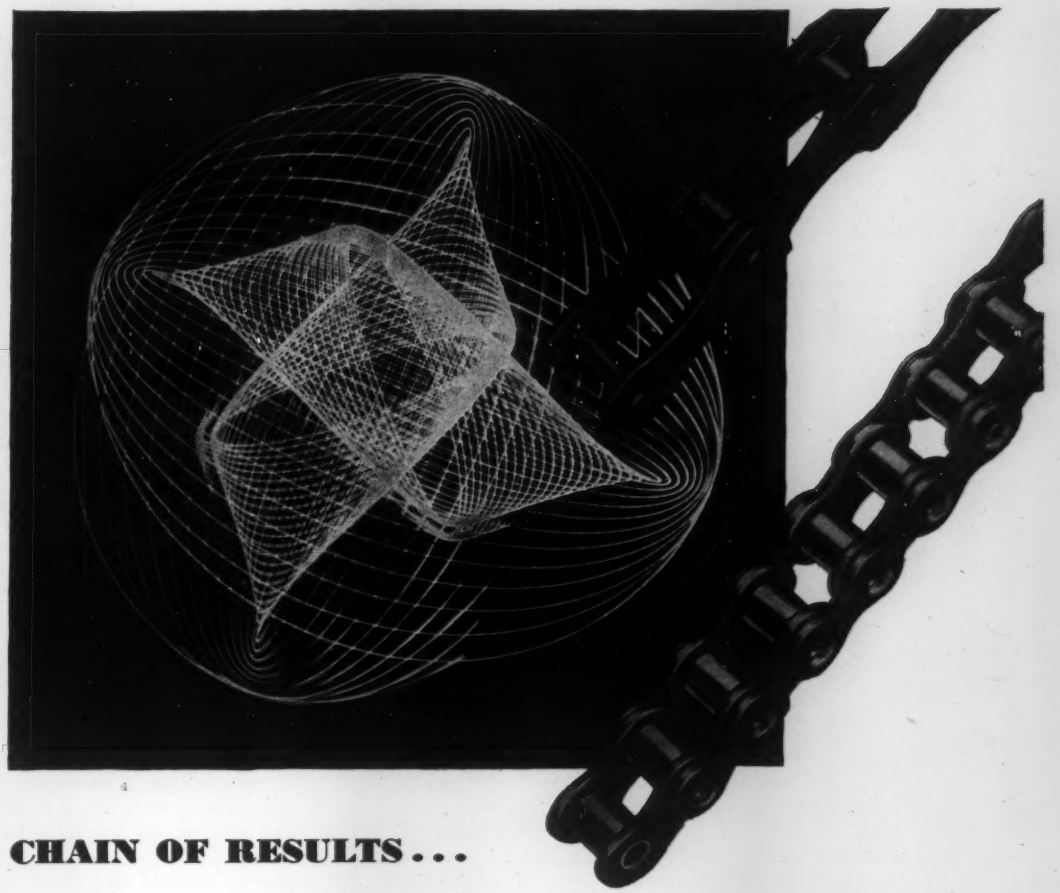
Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

M57-13

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC



CHAIN OF RESULTS . . .

Whitney's Self-Lubricating Single and Double Pitch Roller Chain and *fatigue resistant* Processed Roller Chain are design advancements that get results for machine manufacturers and users in many industries.

They should. For example, Self-Lube Roller Chain outlasts regular chain as much as 5 to 1 under rugged field conditions subject to extremes of dust or mud. In addition, they are widely used on processing equipment where cleanliness is vital and where external lubrication is not practical or desirable. Here, Whitney's exclusive sintered steel chain bushings "oil from the inside" . . . are prelubricated for life.

Whitney's exclusive *fatigue resistant* Processed Roller Chain is establishing new service standards for durability, particularly on problem drives involving unusual operational conditions, stresses and heavy shock loads. This performance comes from the exclusive Whitney *fatigue resistant* process which offsets excessive operational stresses in the chain.

These new dynamic, balanced designs serve better, longer and at less over-all cost. And so does the entire Whitney line of A.S.A. Roller, Silent and Conveyor Chain Drives . . . all precision engineered for top quality.

Whitney Field Engineers provide nation-wide consultant service, backed up by company operated warehouses and alert Whitney Distributors offering a complete off-the-shelf stock service. If you want RESULTS specify WHITNEY CHAIN.

Whitney

CHAIN COMPANY

205 HAMILTON ST., HARTFORD 2, CONN.

ROLLER CHAIN • SILENT CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS

Circle 441 on page 19

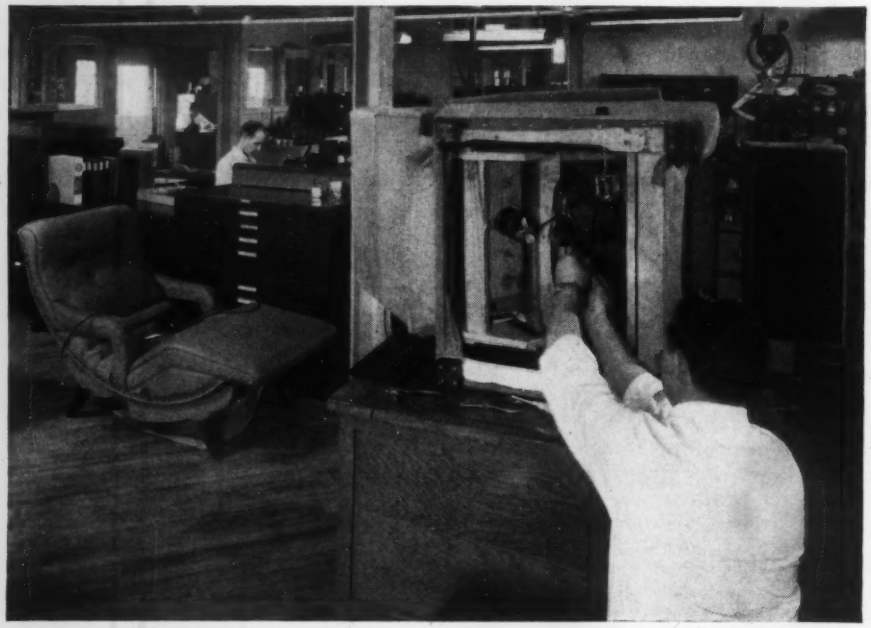
APPLICATION LABORATORIES are called "the customers' labs" at Redmond because here the motors are especially developed for specific customer applications. This photo was made in the induction motor applications laboratory where applications are made for every major industry including air conditioning, ventilating, heating, refrigeration, and appliances.

Redmond Tells How Motors Are Developed

A VISITOR at the Redmond Company's main plant in Owosso, Michigan, will find the complete engineering facilities that enable Redmond, a leading manufacturer of fractional horsepower electric motors, to function as the engineering department of their customers. As James W. Tweedy, President of Redmond, puts it, "We serve as the small motors division of our customers."

Several dozen engineers at Redmond are kept busy with design and application activities. Some of these men are working continually to develop the motors that meet the demand for more horsepower in ever smaller and more economical packages. Two of these new motors recently developed at Redmond are the AL-4 induction MicroMotor and the AM-4 single bearing MonoMotor.

This kind of engineering work requires complete facilities with the



CHAIRS are a typical example of the rapidly expanding markets for fractional horsepower electric motors. Here an engineer in the special products engineering laboratory is installing an actuator motor developed for a chair.

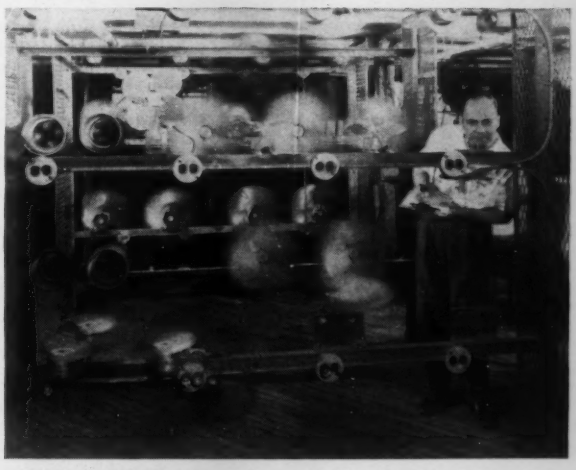
latest equipment. For example, Redmond's modern chemical laboratory is used for making humidity and rain tests, as well as tests on insulation, plating, and paints. In the complete model shop special motors and parts are made.

In the applications laboratories Redmond engineers are continually striving to provide the best, most efficient, and most economical motors to fit the applications of the customers. The units to which motors are being applied are generally brought right into the laboratories, where Redmond engineers develop exactly the most efficient and economical motor to do the job. In these laboratories motors are being applied to a tremendous range of products. Some of these applications are the familiar ones of air conditioners, business machines, tape recorders, furnace blowers, kitchen ventilators, and window fans. Other typical applications that illustrate the ever-expanding market for electric motors are car seat adjustors, lawnmower starters, can openers, bilge pumps, egg washers, shoe buffers, and vending machines.

The Redmond Company, "The Big Name in Small Motors," has the engineering facilities with which to maintain its position as a leader in the design, application, and manufacture of fractional horsepower electric motors.

GENERAL SALES MANAGER of Redmond, M. J. Koenig, left, is also an engineer. Here he is checking on the progress of a starter motor in the special products engineering laboratory. Some of the other units in the picture are blenders, mixers, pumps, and buffers.

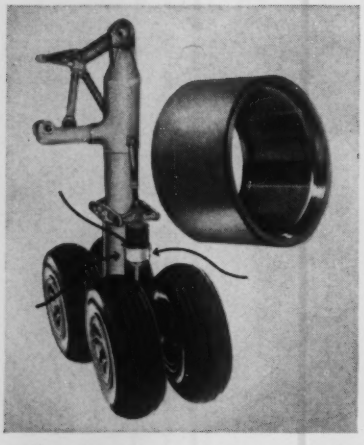
ENGINEERING RESEARCH AND DEVELOPMENT laboratory is looked on as the "company" laboratory, for here motors are continually being developed that meet the modern demands for motors that are smaller, yet more powerful, lighter in weight, and quiet in operation.



LIFE TEST ROOM contains motors that have been running continuously for many years in different positions, at different speeds, and under different loads. In this room there are also ovens to test and evaluate high and low ambient lubricants and lubrication systems. As model changes occur, all new motors immediately take their place here to be life-tested.

Circle 442 on page 19

you put Synthane laminated plastics to work



Synthane (arrow) serves as bearing in landing gear shock struts.

Synthane laminated plastics lead a busy life aloft.

In communications equipment, Synthane is found in hundreds of insulating parts. In aircraft instruments, precision ball bearing retainers and innumerable other parts Synthane is at work. The airframe itself finds Synthane at work in a number of critical applications such as landing gear struts.

The value of Synthane to the aircraft industry lies in its unique combination of properties in one material. It is light in weight (half the weight of aluminum), mechanically strong, dimensionally stable, easily machined and is a good electrical insulator.

Synthane is valued in electrical applications chiefly for its high dielectric strength, low moisture absorption and low dissipation factor. Synthane is available in over 30 standard grades in sheet, rods, tubes or you can avail yourself of our complete fabricating services.

For more information about the many properties of Synthane laminated plastics and how you can benefit by using Synthane materials and fabricating services, write for our latest product catalog. Synthane Corporation, 5 River Road, Oaks, Pennsylvania.

IMPACT STRENGTH

LIGHT WEIGHT

DIELECTRIC STRENGTH

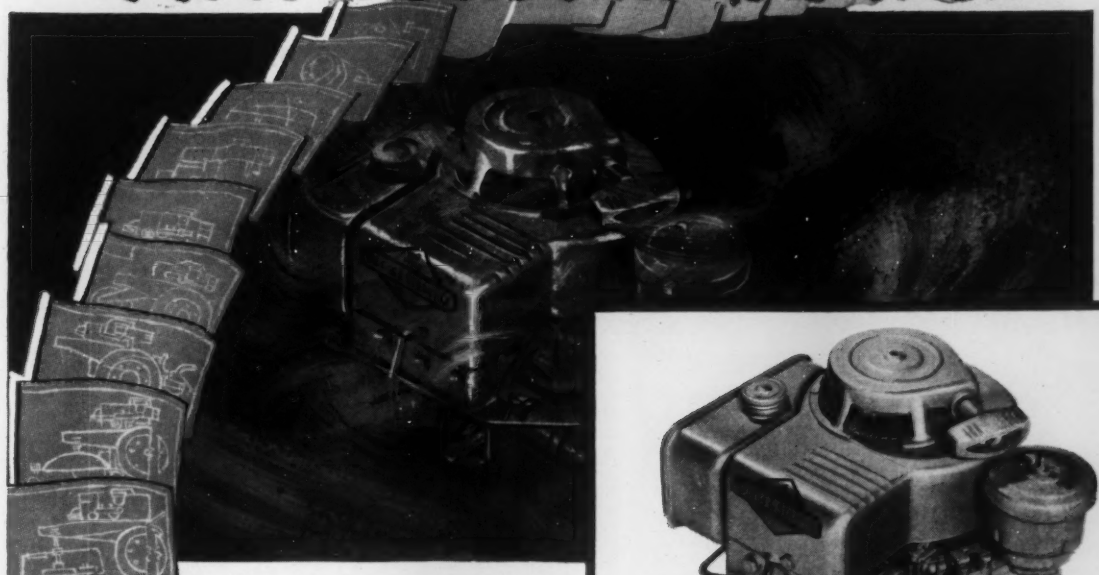
EASILY MACHINED

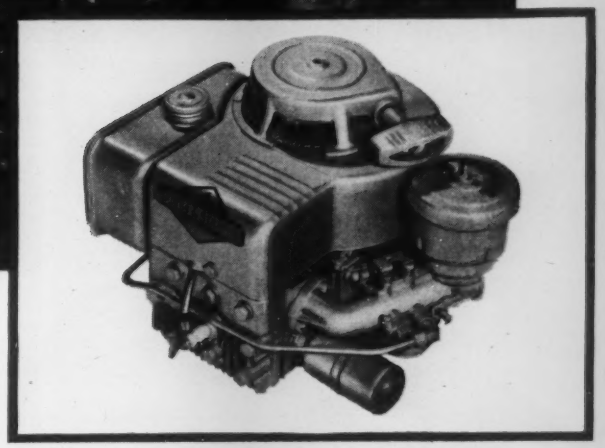
SYNTHANE ...industry's unseen essential

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

Circle 443 on page 19

Man-made dust storms...*





* GRUELING, ACCELERATED TESTS THAT PROVE ENGINE PERFORMANCE

In these dust pit tests, engines receive regular maintenance (more frequently performed) yet operate where men would suffocate.

Why Briggs & Stratton engines deserve your design-decisions

Stringent, never-ending quality control is an important factor in translating superior designs into superior engines. And when it comes to quality control at Briggs & Stratton, nothing is left to chance.

The torture test above is only one of many methods employed to "prove out" Briggs & Stratton 4-CYCLE engines — from design, materials and actual performance standpoints. It's added evidence why Briggs & Stratton 4-CYCLE engines (to 9 hp) deserve your design-decisions . . . why they're *No. 1 in use throughout the world.*

Write now for details on the Briggs & Stratton line.

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

Find Us Fast In The Yellow Pages

— represented by a world-wide network of more than 9000 authorized engine service outlets.

BRIGGS & STRATTON CORP.
Milwaukee 1, Wisconsin

Circle 444 on page 19

AMPCO — ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

Only your *imagination*

limits the ways you can use Ampco Alloys

That . . . and the requirements of the part you're designing

Should your part be sand-cast, centrifugally cast, shell-molded, precision-cast, forged, fabricated or extruded?

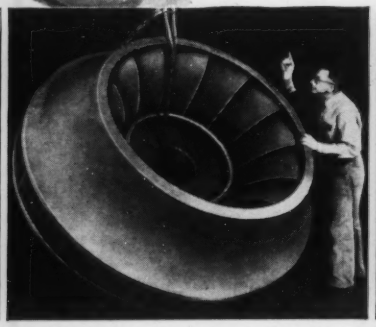
Let an Ampco field engineer help you to select the best, most economical form of production. It's all part of Ampco's one-source service to industry.

And he can help you select the best alloy, too. For among more than 100 Ampco copper-base alloys is the one you need to do the job — to resist wear, corrosion, impact, fatigue — to provide excellent bearing qualities — to retain physical characteristics at temperatures from 600°F down to −400°F.

So call in your Ampco field engineer and get his unbiased recommendations.

Write for Bulletin 33. D-53

5,400-lb. centrifugal casting for flywheel of a marine engine. Ampco makes centrifugal castings from a few pounds to five tons.

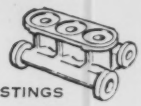


12,000-lb. sand-cast water wheel. Ampco's sand foundry makes any-size casting to 14,000 pounds — sand, shell moldings, cast-to-size, cement.

Ampco's one-source service includes production-run machining of Ampco copper-base alloys to the exacting quality standards of the aircraft industry.

AMPCO METAL, INC. Dept. MD-7, Milwaukee 46, Wisconsin • West Coast Plant: Burbank, California

AMPCO® **THE METAL WITHOUT AN EQUAL**



SAND CASTINGS

SHELL-MOLDED CASTINGS

CENTRIFUGAL CASTINGS

EXTRUSIONS

FABRICATIONS

SHEET AND PLATE

CAST-TO-SIZE CASTINGS

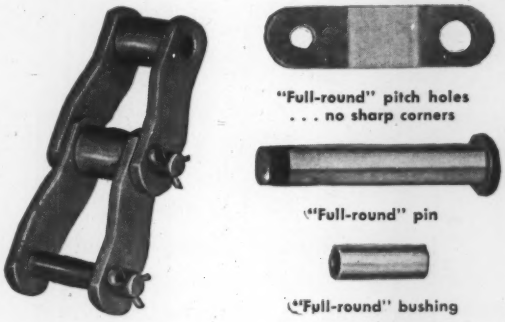
FORGINGS

MACHINED PARTS

Circle 445 on page 19

"Stress raisers" eliminated by Link-Belt LXS chain design

LXS "FULL-ROUND" DESIGN



"FULL-ROUND" DESIGN eliminates stress concentration points. Heat treatment of all parts adds even greater strength and extra wear life to selected steels. Accurate control of these processes avoids brittleness, poor wear values and low tensile strengths . . . and assures uniformity.

Large pins, bushings mean ample live bearing area for long life

For long life under severe conveyor and drive conditions, Link-Belt LXS chain provides extra strength, increased wear resistance and wider application flexibility. This fabricated steel roller chain incorporates many advanced design and manufacturing refinements, resulting in superior ruggedness and accuracy.

Eliminate weak points

"Full-round" design does away with stress concentration points most frequently subject to failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly, increasing chain life.

Pins and bushings are accurately sized for controlled press fit, preventing rotation in sidebars. Made from selected bar steel, sidebars are carefully machined for proper pitch hole size and for maintaining firm, tight press fit of pins and bushings. This assures close control of pitch and proper chain length after assembly.

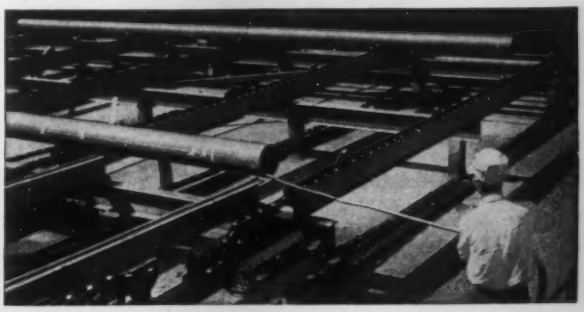
Hardening extends life

Another Link-Belt long-life extra is the controlled hardening of selected steels used in the manufacture of LXS chain. Pins, for example, are made from a tough steel, specially treated for high strength in shear and for maximum wear value. Bushings are properly hardened to shrug off shock and resist wear.

Rollers are accurately machined to assure proper operating clearances and free-rolling action. Controlled hardening gives them the necessary resiliency and durability.

LXS especially popular for exposed drives, high impacts

Link-Belt LXS chain is the long-life answer for exposed drives, abrasive and high-impact conditions. Its large, live bearing area reduces cutting action of abrasives because load is spread over a broad area.



LXS chain provides extra strength, wear-life for heavy-duty conveying

Link-Belt LXS chain has real stamina—as shown in this conveyor application for handling 1000-pound, 40-foot lengths of steel pipe. Thanks to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life for the extra-long conveyors so popular in today's move to mechanization.

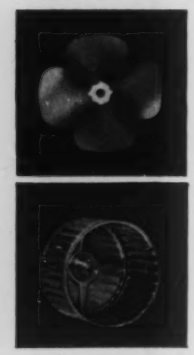
HEADQUARTERS for chains, sprockets and other Link-Belt conveying and mechanical power transmission products is your nearby Link-Belt factory branch store or authorized stock-carrying distributor.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,258

Circle 446 on page 19



ALPHA TO OMEGA

In the design, development and production of the three basic lines of air impellers—fans, blower wheels and complete blower units—Torrington technology is the finest available to industry.

To date, more than half a million design variations of these three types of air impellers have been developed in the successful solution of industrial air moving problems.

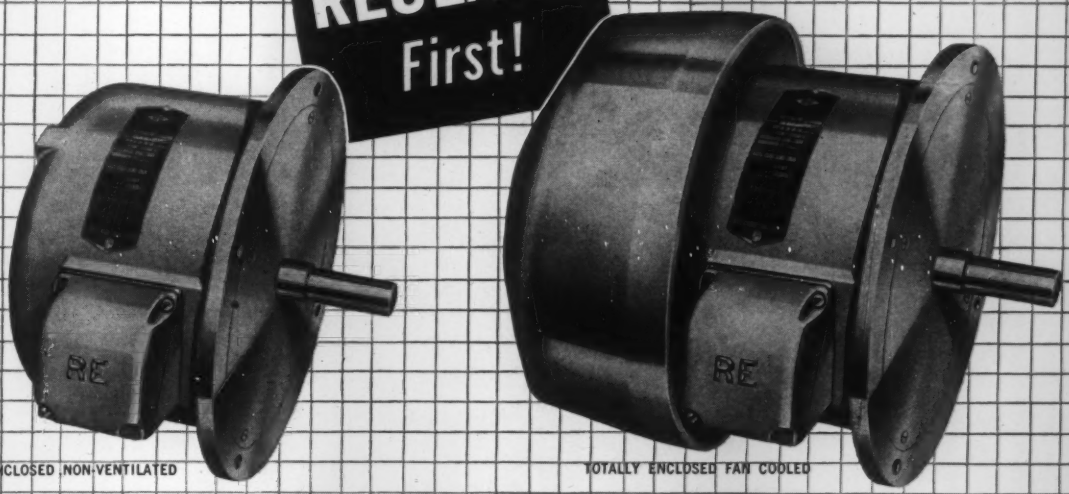
No matter what *your* product or problem, if it involves the movement of air... *talk to Torrington!*

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 447 on page 19

Another REULAND First!



TOTALLY ENCLOSED NON-VENTILATED

TOTALLY ENCLOSED FAN COOLED

MOST BEAUTIFUL MOTORS IN ALL THE WORLD...

NEW REULAND PRECISION MOTORS FOR MACHINE TOOLS

Designed especially for machine tool manufacturers

Reuland precision motors were developed only after giving a lot of careful thought to the problems of the machine tool industry. They are not just another line of motors that can be "made to fit," but rather, a complete new type especially made for machine tool manufacturers.

They are available in T.E.N.V. and T.E.F.C. types. Small, compact and featuring the very latest in lightweight materials.

For good looks and precision operating characteristics, there is nothing on the market to equal these jewel-like units.

Precision balance

Reuland motors are built to precise specifications like a fine tool. Each unit is dynamically balanced at the factory to assure vibrationless operation.

Heavy-duty ball bearings, located at each side of the rotor, assist in maintaining this characteristic which is so vital to precise work. Exact tolerances are likewise maintained throughout final assembly.

Low inertia rotor

The radial air gap design of these motors permits the use of a lighter weight, low inertia rotor. This light weight, low inertia feature assures smooth starts and quick stops.

This rotor is also of a special narrow design which has shortened up the overall length of the motor to give a thinner, "wafer" effect.

Smooth-finished castings —pleasing lines

The smoothly finished surfaces of Reuland machine tool motors are a match for the most expensive tool. All castings are specially processed for smoothness and are given a baked enamel finish.

This fine-quality finish, together with the motors' naturally pleasing lines, assure a harmonious blend with the lines of every machine tool on which they are mounted. (When desired, the motor's frame size can even be varied to fit an *exact* contour of the machine.)

Other Reuland firsts!

1. Motor with internal fluid coupling
2. Spline-coupled hydraulic pump motor
3. Foot-mounted disc type magnetic brake with self-contained bearings and shaft
4. "Through-Shaft" magnetic disc brakes
5. Slip Ring motors in small #66 frames
6. All-aluminum motor frames
7. "Xpandable" motor design

Use these other free Reuland Services

RE®

Special-Motor Library

Don't ever pay for special-motor development costs before you check this free library. Contains valuable data on hundreds of unique, specially designed motors. Send for free "how to use" booklet.

Standard Motor Catalog

Contains engineering information on Reuland's complete line of standard motors and motoreducers. Sent free on request.

REULAND MOTORS

REULAND ELECTRIC COMPANY

Western Division: Alhambra 88, California
Eastern Division: Howell 88, Michigan

Distributors in all principal cities

Circle 448 on page 19

HOW USS "T-1" STEEL IMPROVES

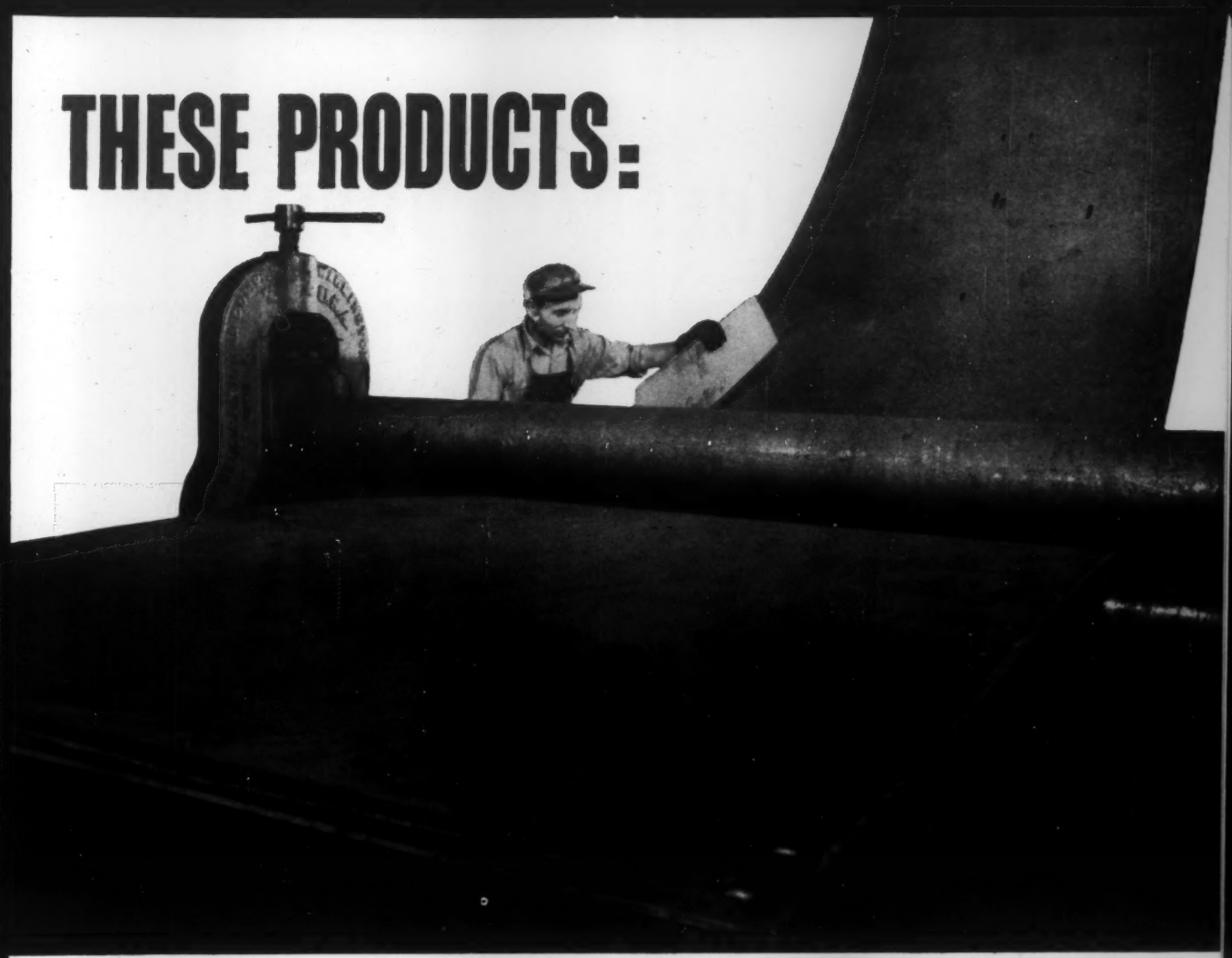
▲

Eliminates Normalizing. A-1 Bit and Tool Company, Houston, Texas, has converted exclusively to USS "T-1" Steel for jigs and fixtures on its turret lathes. The reason: USS "T-1" Steel, being already heat-treated, doesn't require normalizing before final machining. "T-1" doesn't warp and distort during welding, and it is easy to weld. Jigs now are machined, welded, and ready for mounting. USS "T-1" Steel saves money, speeds production, and reduces rejects.

◀

Increases Durability of Buckets. Oaks Welding, Incorporated, Columbiana, Ohio, repairs mining equipment on a custom basis. They rebuilt the 4½-yd. dragline bucket shown here with USS "T-1" Steel. Sides, bottom, and runners were made from USS "T-1" Steel . . . are actually far stronger and more durable than when the shovel was new . . . are better able to withstand severe impact abrasion in all kinds of weather.

THESE PRODUCTS:



▲ **Simplifies Fabrication.** Fairmont Machinery Company, Fairmont, West Viriginia, is using USS "T-1" Steel in thicknesses up to ⅜ inch to build an *unlined* coal storage bin. "T-1" Steel's abrasion and corrosion resistance make it an ideal choice for this type of service. In fabrication, high-yield-strength USS "T-1" Steel was cold formed on equipment normally used to form carbon steel.

This new coal storage bin will be welded in the field to cut costs. It will be simpler to build because it will need fewer stiffening members and will be lighter in weight than typical coal storage bins.

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,00 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact abuse at sub-zero temperatures. Its excellent weldability can help you to cut the cost of fabricating highly stressed parts and to reduce repair and maintenance expenses. Its good creep rupture strength can help you to put more durability in equipment that operates at temperatures as high as 900 degrees F.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Pittsburgh 30, Pennsylvania.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

"USS" and "T-1" are registered trademarks.

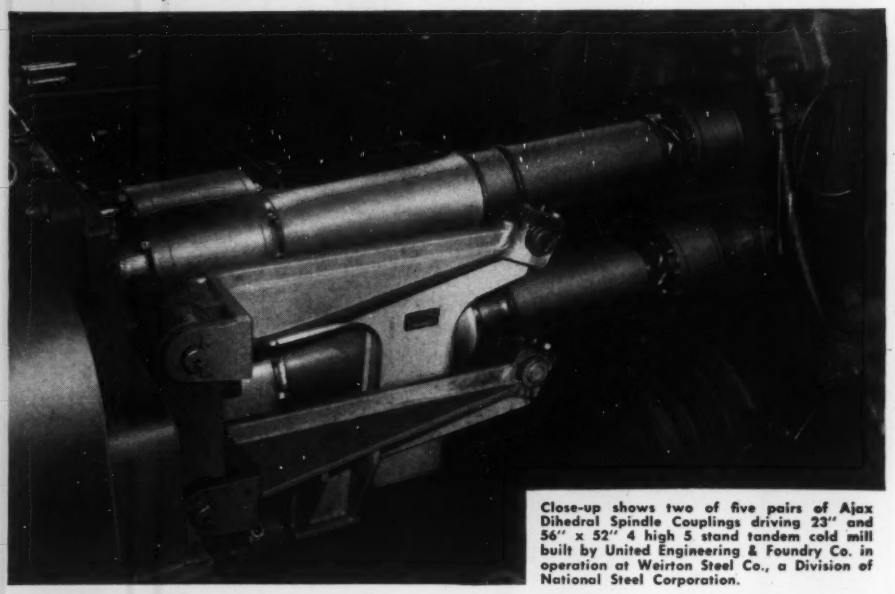
Circle 449 on page 19

USS

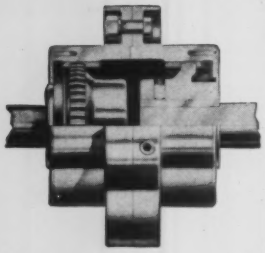
UNITED STATES STEEL

AJAX® DIHEDRAL COUPLINGS

SHORT CUT TO MAJOR PRODUCT IMPROVEMENT

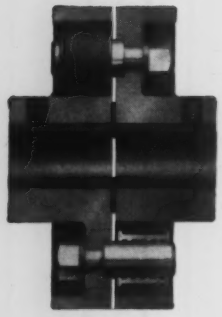


Close-up shows two of five pairs of Ajax Dihedral Spindle Couplings driving 23" and 56" x 52" 4 high 5 stand tandem cold mill built by United Engineering & Foundry Co. in operation at Weirton Steel Co., a Division of National Steel Corporation.



AJAX SERIES D-100

Dihedral Couplings handle shaft misalignment — offset and angular, up to 12°. Patented tooth design permits far less tooth clearance and provides more tooth area in contact under misalignment than with any other shaped tooth.



AJAX SERIES D-3000

Dihedral Couplings handle shaft misalignment up to 3° — yet cost no more than ordinary gear type couplings that have far less misalignment capacity. Johns-Manville "Clipper" Seals keep lubricant in and foreign matter out.

AJAX RUBBER-BRONZE BUSHED COUPLINGS

are built in a wide range of sizes and capacities with standard couplings made of forged steel or cast semi-steel. Flanges can be machined from aluminum, bronze and other metals, and can be chrome or cadmium plated for protection from adverse atmospheric conditions.

● Ajax Dihedral Couplings are major factors in new, improved product quality, machine performance and operating efficiency.

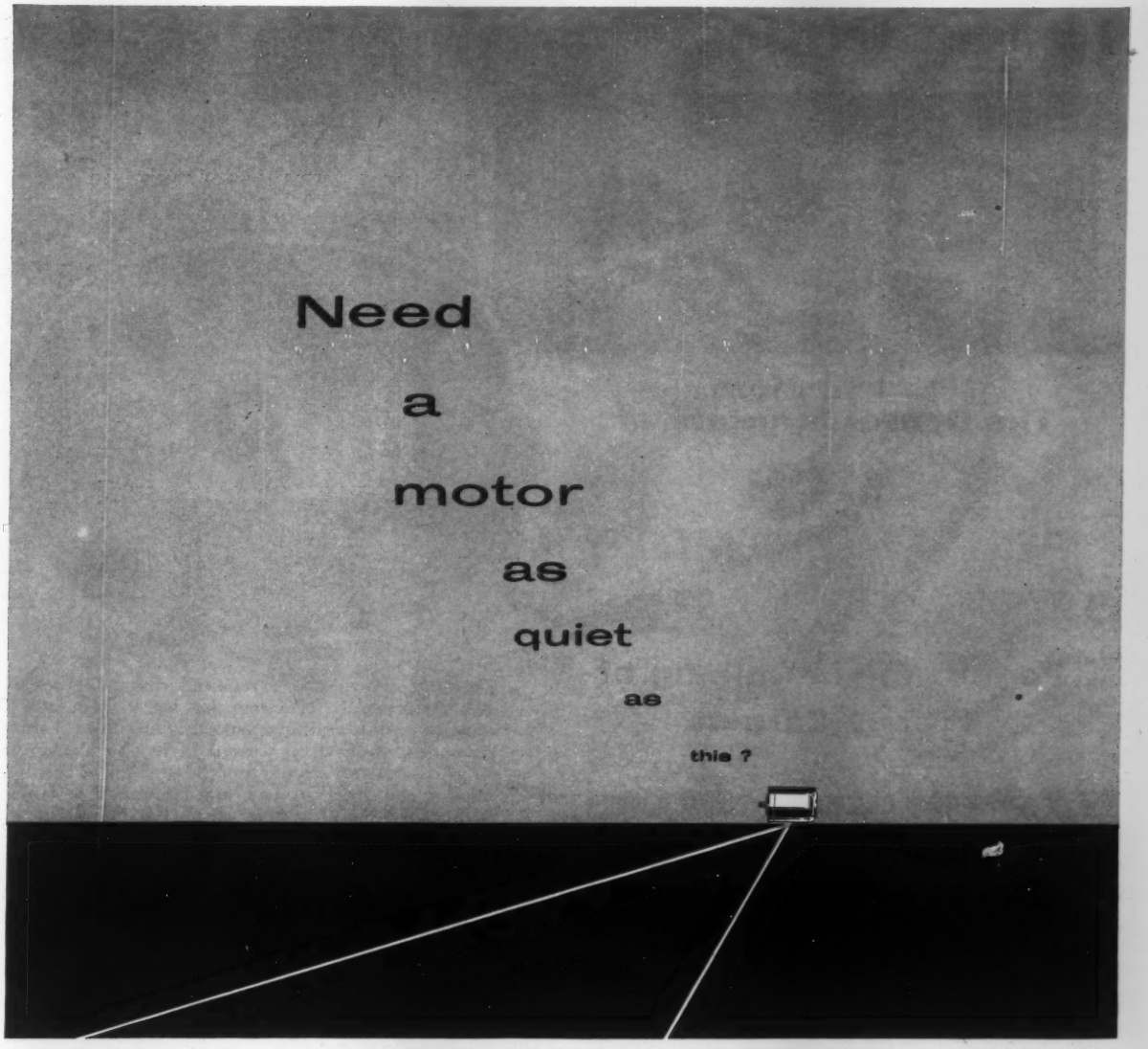
Ask any engineer — their selection of component parts rests upon a reliable source of technical information, and upon proving respectively the product and performance data. Ajax Dihedral Couplings handle any combination of angular and offset shaft misalignment up to 12° — greater capacities are available on special order. That explains why design and plant engineers specify and insist on Ajax Dihedral Couplings. Their proven performance in protecting millions of dollars worth of machinery in virtually every industry is why builders and users alike depend on Ajax Dihedral Couplings.

Write for your personal copy of the new Ajax Bulletin No. 62. It contains the misalignment capacities of every coupling type and size in the Ajax complete line of Flexible Couplings, or refer to SWEET'S Catalog, Product Design File.

Patented or Patents pending in U.S.A. and foreign countries.

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, NEW YORK

Circle 450 on page 19



FREE! This 24-page booklet explains when to specify *Customized* motors, shows design variations, illustrates case histories. Write Jack & Heintz, Inc., 17626 Broadway, Cleveland 1, Ohio.

Call Jack & Heintz—America's leading specialist in *Customized* motors, ⅛ to 5 hp (⅓ to 15 hp in submersible motors). We'll gladly devote as much time as it takes to design the motor that hushes operation of your product . . . a motor that *electrically*, *mechanically* and *physically* fits your product perfectly.

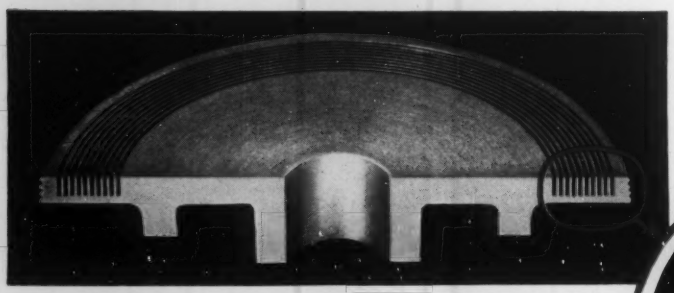
Customizing electric motors to meet the specific requirements of original equipment manufacturers *is our business*. Because we're organized that way, costs are reasonable to get the quiet, or torque or envelope you need. We can stretch a motor tall, squat it flat, customize it for ambient temperature rating. Make it submersible in a wide range of fluids. Give it flushness or a special finish. You name it!

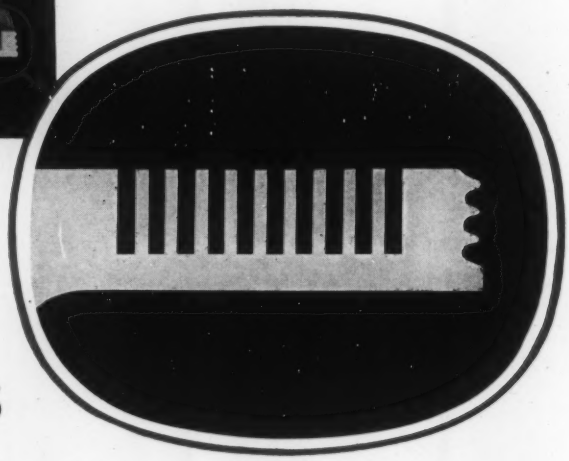
So go ahead freely! Design your product to do its job. We'll fit a motor to it that will make your product perform the way you want it to . . . look as good as it should . . . last as long as you say it will . . . and sell faster because of it.

JACK & HEINTZ *CUSTOMIZED* ELECTRIC MOTORS

Circle 451 on page 19

Do Your Castings Require Sharp Corners *Like These?*





The Denser Structure of EATON PERMANENT MOLD GRAY IRON CASTINGS

Permits the Machining of Precise Corners

The fine dispersion of graphite in Eaton Permanent Mold Iron and its dense, non-porous, homogeneous structure make it an ideal material for many difficult machining operations where accurate dimensional results and sharp corners are essential.

Because its superior structure permits the machining of extremely thin sections and has the ability to take a high surface finish, Eaton Permanent Mold Iron is recommended for such critical applications as bearing retainers, connecting rods, pulleys, carburetor bodies, valve bodies, and service valves.

If you have applications which require these exceptional characteristics, our engineers will be happy to work with you.

The part shown above required that 10 grooves, .023" wide and .125" deep, leaving 9 lands .015" wide, be rapidly and simultaneously machined. Eaton Permanent Mold Iron proved to be the ideal material—completely eliminating the problem of curling chips in the small grooves, and crumbling of lands during machining.

Check these Important Advantages:

- ★ **Dense, non-porous, homogeneous structure**
- ★ **Freedom from inclusions**
- ★ **Excellent tensile strength**
- ★ **Ability to take a high surface finish**
- ★ **Freedom from leakage under pressure**
- ★ **Intricately cored sections**
- ★ **Uniformity of castings**
- ★ **Higher machining feeds and speeds**
- ★ **Substantially increased tool life**

Send for Illustrated Descriptive Literature

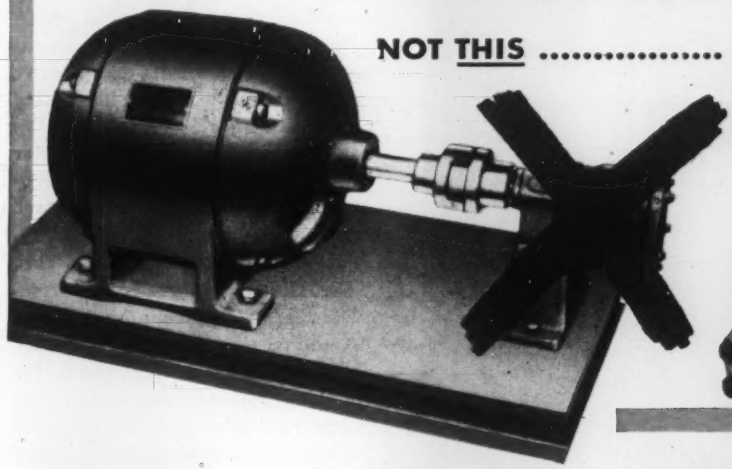
EATON

FOUNDRY DIVISION
MANUFACTURING COMPANY
VASSAR, MICHIGAN

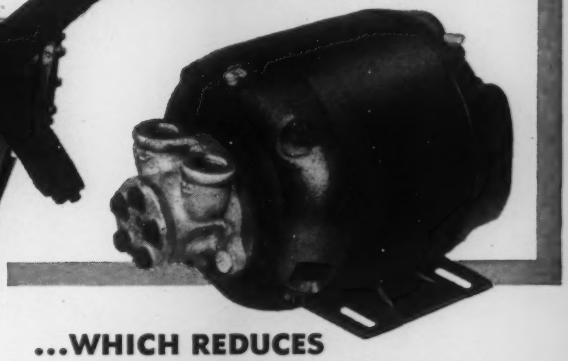
PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Motor Truck Axles • Permanent Mold Gray Iron Castings • Forgings • Heater-Defroster Units • Automotive Air Conditioning Fastening Devices • Cold Drawn Steel • Stampings • Gears • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

NOW AVAILABLE!

New TUTHILL Positive Displacement Pump-and-Driving-Motor Units Require Less Space ...Have No Couplings, Adapters or Base



NOT THIS ..... BUT THIS TUTHILL PROMPTLY-DELIVERED SPACE-SAVING UNIT



● Now there are *two* means by which the problems of space, weight, time and cost can be solved in the application of hydraulic, oil burning and lubricating pumps and motors to industrial equipment.

First, the use of compact, custom-built TUTHILL "POWERMITE" pump-and-driving-motor units for original equipment manufacturers having QUANTITY requirements.

Second, the use of compact, standard, promptly-available TUTHILL pump and driving motor units *for individual applications which do not warrant custom design.*

PUMP MOUNTED ON THE MOTOR

Both provide—with no coupling, adapter, or base:

1• Important savings in space.

2• Reduced weight for less shipping and handling costs.

3• Fewer components, thus less expense.

4• Less assembly time.

A typical standard TUTHILL pump-and-driving-motor unit is shown above. Note that *the pump is mounted on the motor*...eliminating the need for coupling, adapter and base...and time normally required for their assembly. In comparison with a regular assembly, the new driving unit saves a minimum of 6 inches in space and weighs several pounds less. The TUTHILL rotary positive displacement pumps used in these driving units range in flow capacity from 20-300 GPH and in pressures up to 1500 PSI. The combinations include ¼ HP motors and larger.

...WHICH REDUCES COST AND TIME ($$) TOO

FOR THE OCCASIONAL USER

These latest TUTHILL units extend the advantages of our compact, original equipment design to the occasional user of pump-motor units—the industrial firm interested in individual or minimum quantity orders and prompt delivery.

TUTHILL Positive Displacement motor-and-pump units offer a wide variety of combinations for use in hydraulic, oil burning, lubricating and other services involving many different fluids. The model shown has a capacity of 90 GPH and a ¼ HP motor with a speed of 1750 RPM.

Use the attached coupon—or write TUTHILL PUMP CO.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois

Please forward complete information on the new TUTHILL pump-and-driving motor units:

☐ for small quantity application
☐ for large quantity application by original equipment manufacturer
☐ please have your representative call

NAME_____ TITLE_____

COMPANY_____

STREET_____

CITY_____ STATE_____

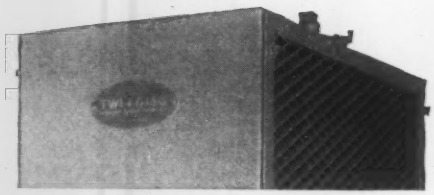
Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

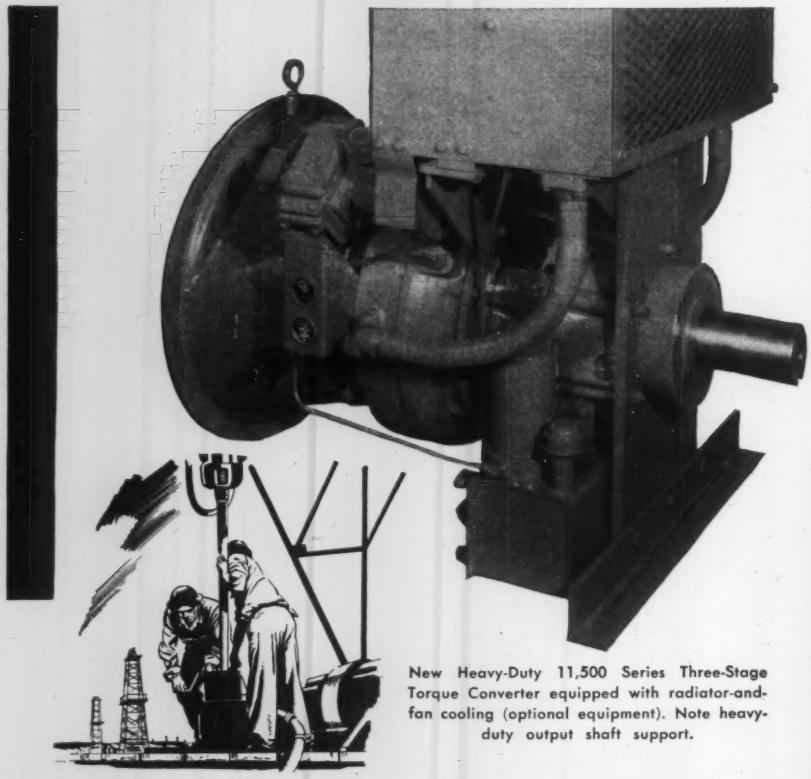
953 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

Circle 453 on page 19



Twin Disc announces new Heavy-Duty 11,500 Series Torque Converter



New Heavy-Duty 11,500 Series Three-Stage Torque Converter equipped with radiator-and-fan cooling (optional equipment). Note heavy-duty output shaft support.

Further extending its line of three-stage torque converters, Twin Disc Clutch Company now offers industry an additional version of its popular 11,500 Series Three-Stage Torque Converters.

Designated the Heavy-Duty 11,500 Series (a Standard-Duty version will be continued), the new units have a maximum rating of 586 hp at 2200 rpm. Maximum input torque is 1400 pound-feet. Impellers are available for specific torque ratings of 340, 390, 450 and 540 pound-feet.

Current production units include the Model CF, which provides a clutch at the flywheel, and the Model F, which is connected to the flywheel with a driving ring.

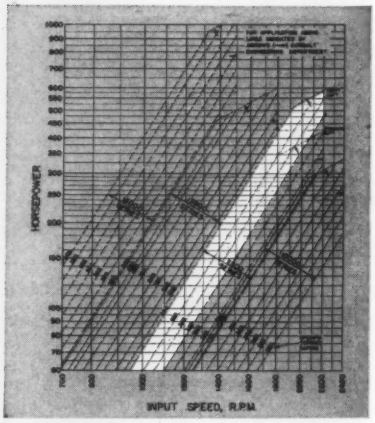
A Twin Disc C-3 Rear End, with the output shaft supported by two heavy-duty roller bearings, is available with either model, permitting maximum output sidepull.

The complete line of Twin Disc Three-Stage Torque Converters includes five distinct sizes; the 10,000 Series, Standard-Duty 11,500 Series, Heavy-Duty 11,500 Series, 13,800 Series and the 16,000 Series. The line offers 33 specific torque ratings and input and output arrangements to meet virtually every industrial requirement from 60 to 1000 hp and from 700 to 2400 rpm.

These three-stage torque converters have long proved themselves on such applications as crawler tractors, drilling rigs, shovels, yarders, locomotives and many, many others. They offer such advantages as multiplying engine input torque (up to 6:1) exactly as required by load . . . cushioning out destructive shocks and vibrations . . . minimizing maintenance and downtime . . . and *producing more work on a hp-cost basis.*

Twin Disc, the only manufacturer producing both three-stage and single-stage designs, offers single-stage torque converters for engines producing 30 to 212 hp. Besides this, Twin Disc makes available a complete line of fluid couplings, to 850 hp, and friction clutches, to 1050 hp.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois . . . with parts and service facilities throughout most of the world.



Unshaded area in above curves compares hp and rpm characteristics of the Heavy-Duty 11,500 Series Torque Converter with other Twin Disc Three-Stage Torque Converters.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

Circle 454 on page 19

MACHINE DESIGN
July 25, 1957

A Time for Appraisal

RECRUITING, both of new graduates and of experienced engineers, is still being pursued intensively —but with a difference. Engineers are discovering that recruiters offer good jobs only to those with special qualifications. In other words, the "shortage" is now, even more clearly than before, one of quality and experience rather than quantity.

New graduates, as yet professionally untried, will still be hired with less discrimination than older hands. They have potential and they can be trained, so the reasoning goes. But demand for engineers is unmistakably slacking off and in some geographical areas there is even a numerical surplus.

Long range, we don't foresee anything approaching hard times for engineers. But some degree of expertness in a needed area, or unusual intellectual capacity, will be prerequisites for a well-paid engineering job.

Competition for the privilege of going to college, occasioned by the bumper crop of college-age youngsters, should result in higher quality graduates. Older engineers who just "scraped through" or have failed to develop professionally will find it increasingly difficult to keep up.

For management the situation offers challenging opportunities. Now is the time to evaluate engineers and the jobs they are doing. Top-drawer men can be freed for creative engineering by relieving them of subprofessional chores. The less professionally competent engineers, being in better supply, provide a source of manpower for many of the semiengineering chores discussed in G. William King's article beginning Page 72 of this issue.

For engineers it is a critical time to take stock of themselves and plan the direction of their careers. Those who lack the interest or intellectual capacity to be outstanding in strictly design engineering accomplishment need not despair. Their engineering training and background have tremendous value for many rewarding jobs related to engineering, including management, production and sales.

But top-notch engineers will always be in short supply. Management, aware of this, should provide more than adequate professional and economic status to keep such men in the kind of jobs where they are urgently needed.

Colin Carmichael

EDITOR

Is the engineering shortage a lack of manpower or is it inefficient use of available manpower? Regardless of the answer to this debate of the day, more true engineering capacity is certainly needed.

An eventual increase in the total number of available engineers is of small help to the company that needs more engineering capacity immediately. Increasing engineering efficiency is the only practical answer for the near future.

To aid this effort, here is a realistic discussion of problems often encountered and practical ideas for their solution.

Tools for alleviating The Engineering

By G. William King
Consulting Engineer
Springfield, Pa.

SHORTAGE of engineers, and ways to combat this shortage, are subjects of great concern and comment. Fortunately, there are a number of management tools that can be used to improve the operating efficiency of an existing engineering department by several-hundred per cent. One of the most practical ways to alleviate this shortage of engineering personnel is to secure more efficient utilization of the individual engineer's time.

Technical talent is all too often being used today according to outdated procedures. The major portion of the average engineer's day is spent on nontechnical work such as paper work, expediting, follow-up and similar repetitious tasks. If the engineer can be relieved of his routine and nontechnical duties, the problem is well on its way toward solution. If the elements of the problem can be measured, a good deal becomes known about the problem. Therefore, the first chore is measurement—before the practical solutions can be developed.

Measuring Effectiveness: This is difficult to do because the output is not in production terms of pieces per minute or assemblies per hour. Frequently in the past, creative personnel have been gaged by the number of patents granted. This is a valid measure when the output normally reduces to patentable ideas. Unfortunately, a major portion of creative effort is not patentable according to patent office rules. An efficient familiarity with existing knowledge, hardware or techniques is not patentable. Some managers rate their subordinates on the basis of idea production. However, some individuals are prolific in original, recognizable ideas; others are not. Even the definition of an idea is clouded by personal interpretation and opinion and therefore can not be universally accepted as a measure.

Since measurement of creativity is not as yet a definte science, it may be well to isolate the problem. If the diligent engineer is stripped of nonengineering burdens, it may be assumed that his time is then predominantly creative. Nonengineering work is much easier to recognize. This work may be defined as effort which can be shifted completely or in part to trained semitechnical or nonengineering personnel. Typical duties which fall within this definition are listed separately.

Some of the listed duties are marginal because they do require some engineering control. However, many of them do not. Engineers in some organizations are burdened completely by nontechnical work. In other organizations, engineers enjoy creative work, completely devoid of nonengineering duties. At any single time, these two extremes may exist unnoticed within the same company structure. Unfortunately, the former extreme usually comes closer to describing the general situation.

The percentage of an engineer's time being de-

Shortage

voted to engineering work is frequently questioned. An informal verbal poll of a reasonably large group will produce answers which may be surprising to the layman but are quite real to the practicing engineer. This may be verified by an experiment. In 10 to 15 minutes, a department head may circulate very informally through an engineering group and ask each engineer what is being done at that particular moment. The results are classified according to engineering or nonengineering functions, being guided by the listing given and by the definition of "nonengineering" work. The percentage of engineering activity versus the number of engineers sampled should be calculated. In an aircraft concern, a poll—actually a crude motion analysis—showed engineers spending 7½ per cent of their time on actual engineering work.

A major difficulty lies in the recognition of the problem. A typical reaction is, "Why spend time to clean up the house for a 10 per cent improvement when the real requirement is a 200 per cent change?" If a group is operating at typical efficiency, there is considerable at stake. Technical manpower is not available by present organization standards; therefore, improvements must be made to use those available.

Salary structure has presented an impedance in recent years. There is too little salary difference between engineers and other semitechnical or nontechnical personnel; therefore, there is little incentive to differentiate markedly in their duties. Only

Nonengineering or Semiengineering Duties

Frequently these operations are found being performed by engineers. For maximum efficiency, all should be delegated to nonengineering personnel.

- Parts ordering
- Part and material procurement
- Purchasing follow-up
- Routine design
- Drafting
- Drafting follow-up
- Model making
- Model follow-up
- Factory follow-up and co-ordination
- Trouble-shooting
- Vendor contacts
- Vendor follow-up
- Expediting
- Correspondence
- Routine testing
- Component testing
- Component selection
- Component layout and arrangement
- Repetitious specifications
- Bookkeeping
- Personnel activities
- Sales work
- Routine computations
- Scheduling
- Estimating
- Paper work and blueprint handling
- Report compilation
- Report writing

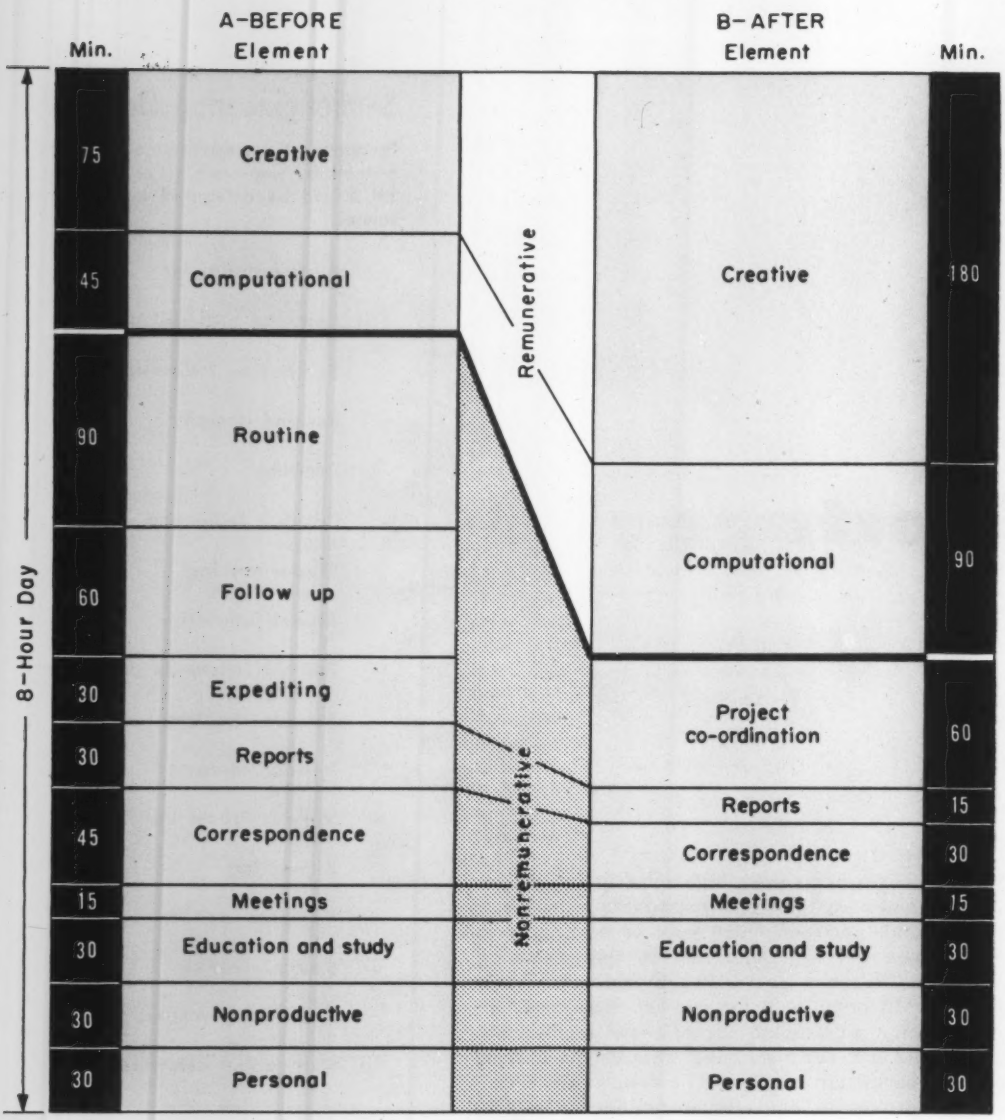


Fig. 1—Technical-organization procedure study, showing typical utilization of engineering time before and after reorganization. Useful engineering time is more than doubled by shifting nonengineering work to second-echelon personnel.

of very recent date has there been mumbling about $10,000 "clerks" being somewhat expensive and extravagant.

The question arises, "What is the maximum effectiveness that can be expected, based on an eight-hour day?" A technical-organization procedure study of an engineering day is likely to look like Fig. 1*a* before correction. Fig. 1*b* shows a typical day after reorganization has been in effect six months to a year.

Reorganization Problems

There are a number of diverse problems that restrict corrective action. These problems must be recognized and solutions found.

Human Nature: Most of us are "judicial" thinkers. An executive's advancement usually depends largely upon how well he exercises his judgment. A vice president of a large corporation said, "Almost all of us rate each other on the basis of judgment—we are far more apt to look up to the other fellow if he makes no mistakes."

Inherently, an organization resists changes. With such an overbearing judicial precedence to deal with, the bright, aspiring engineer is unlikely to jeopardize his career by upsetting many years of

precedence and attack the problem "head-on," knowing full well that it is beset with pitfalls and reverses. Reorganization, as a result, is more likely to be gradual evolution. But the danger is that evolution cannot keep pace.

Employee Relations: The supporting personnel that the engineer must lean on to alleviate his extracurricular burden must be numbered among the ranks of clerks, technicians, financial, technical, and shop help.

In many companies these groups are organized. Each job has a description which spells out in detail precisely what is contained in that particular job, with little or no flexibility. In most cases, the job description has been in existence a number of years. The worker may stand on his right to do no more or no less than his job contract. Thus, the more liberal or more aggressive individual is prevented from stepping outside his job description by the reaction of his fellow workers. A career union leader is usually too busy satisfying his constituents' short-range problems to sit back and take a long-range look at the overall picture.

Frequently, management is hesitant to approach the union with changes for fear of upsetting existing relations; therefore, "status quo" prevails. This burden of inflexibility must be shifted. Union and management must sit down in good faith and put new jobs on a trial basis to see how well they will work out in practice.

Overhead: For years, management and department heads have used their overhead rate (per cent of direct labor) as a measure of efficiency. If a manager had considerable direct labor, little supervision and little supporting help, his overhead was low and he was looked upon with favor. It may have been that his direct labor was performing menial tasks, and that his supervision was spread very thin, but nevertheless, his overhead picture was "good."

While this concept may be questionably adequate for a production department, it has no place in engineering research and development. Nonetheless, it still prevails. Since the emphasis is to see that there is no more overhead than necessary, and since it is much easier for a manager to determine if supporting help is busy or not, the department loading is likely to look like Fig. 2*a* with the supporting personnel load as 100 per cent, and the engineer assuming the overload of each group. In order to carry the engineering load along with all the rest of the supporting duties, more engineers are required.

Since engineers are in such short supply, it is reasonable to reverse the loading picture. At the risk of high overhead, which in this sense can be considered high efficiency, supporting help should be provided in abundance and the engineers trained to use them. The more desirable work loading would look like Fig. 2*b*. The underload of supporting personnel can be balanced out, but not at the expense of engineering time.

The problem adds up to the need for a complete reversal of emphasis. This change cannot be completed until a related problem is solved—that of policy.

Government Policy: The largest requirement for technical help is in government military work. Aircraft, weapons, missiles and atomic energy have demanded engineering help in quantities never before experienced.

Personnel directly contributing to a military project, such as production workers, aircraft sheet-metal fabricators, draftsmen and engineers, are considered direct labor in the eyes of a contracting officer. Personnel such as expediters, clerks, stenographers, budget and financial help are considered as overhead. Since the government supports direct labor and overhead at industries' established rates, there is a sustaining pressure to keep overhead personnel to a minimum and overload them. In doing so, the engineer assumes the burden of the overflow, which cuts seriously into his technical contribution. There has been no analysis that isolates his engineering work from his nonengineering work. Therefore, over a period of years, he has become a high-priced clerk. This problem sums up to a need for flexibility in overhead rates when handling government work.

Training: Technical training of the engineer pays off in the long run. Considerable thought has been given toward the location of research centers near colleges and universities. Unfortunately, the training of second-echelon personnel has taken a back seat. The usual practice, when it is recognized that an engineer needs support, is to assign him a man and let him train him—adding to the already heavy burden of nonengineering effort.

The prevailing argument is that each engineer has his own specialty and must therefore give personalized training. Frequently it is not recognized that the trainee must know and deal with the same complicated organization as the engineer. The root of the problem is that most training groups are completely understaffed (overhead problem) and are not able to perform the training functions that are necessary.

Professional Society: Engineers through their professional societies can influence many of these problems. By comparative organization standards, engineers are one of the most disorganized groups in the country. The medical and bar professions have unified societies. Engineers, as a contrast, have a host of professional societies and not one of them is able to speak for the entire group. Some fresh thinking on a unified approach certainly seems to be needed.

Solving the Problem

All the problems contributing to the engineering shortage pile up into what may seem an unsur-

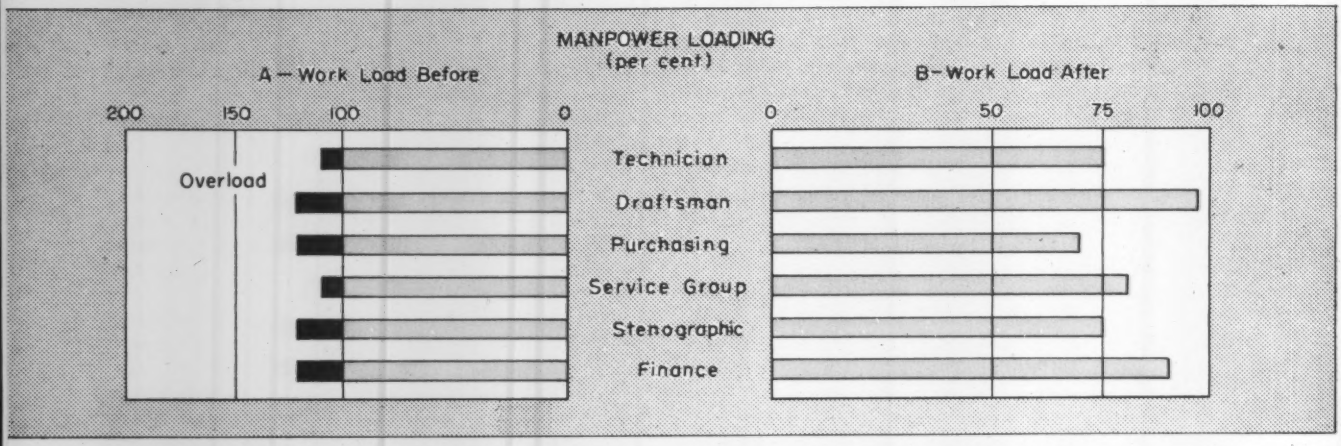


Fig. 2—Due to predominant concept of overhead as applied to the engineering department, nonengineering personnel are frequently overloaded, *a*, with the engineer assuming the overflow. The engineer works as a co-ordinator and does work that others have no time for. Little engineering time is available for purely engineering duties. Re-organization keeps nonengineering staff at less than full-load capacity, *b*, so that engineers are not forced to accept overflow. Engineering personnel are thus free to devote maximum time to engineering duties.

mountable heap. It falls on management of both government and industry to solve them. Recognizing the problems, of course, is the first step toward the solution. There are a number of management tools which will contribute favorably to a solution in an average engineering department.

Engineering Procedures: The cycle of project inception and reduction to practice can be materially aided by a few simple procedures.

CREATIVE THINKING: These techniques have proven themselves as a method of producing literally hundreds of ideas for solutions of problems. Properly applying these methods to problems in a new engineering project, a group may run the gamut of solutions in 30 minutes that ordinarily may take days or weeks for a lone thinker to develop.

PLANNING REVIEW: This is the process of reviewing the scores of ideas produced by creative-thinking techniques, analyzing them, and picking out the desired course of action for the project to follow.

The usual development cycle then takes place with the cumulative effort resolved into preliminary-drawing form in preparation for a design review.

DESIGN REVIEW: The design engineer should review the entire effort before a design-review board, composed of engineers who have had heavy experience within the scope of the project. Additions or corrections are suggested at such a meeting. Drawings are completed in finished form and the first model is built and tested. If the unit is to be made in high production, the next step is production review.

PRODUCTION REVIEW: The project is again reviewed in similar fashion to the design review, except that special consideration is given to production problems and economies.

Engineering Facilities: Office equipment, such as calculators and dictation machines, should be within easy reach. They can be real time-savers, but not if the engineer has to wait in line to use them. Writing by longhand is inefficient. Ideas often come in such rapid succession that by the time an engineer is able to write down his initial thoughts he has forgotten the balance of them. Dictation equipment at the fingertips of an engineer, trained to use it, facilitates immediate transcription of the ideas he wishes to retain and greatly shortens the communication cycle.

Reference Information: Design handbooks and engineering standards provide ready reference to proven design techniques and can prevent the engineer from having to start from scratch on his project.

Office Systems: A paper-simplification study can reduce the paper work usually associated with an engineering office. Every group has its own particular formats, often in duplication with similar types in the same work area. Forms have a habit of growing, "like Topsy," for specific purposes and are then used afterward with no established procedure. The eleventh and twelfth copies are usually made to cover a situation established years before. A careful analysis of paper work should be made periodically to reduce it by cutting back on all extraneous material and distribution.

Job Descriptions: These should be reviewed occasionally. Descriptions are useful reminders to the engineer that he may be performing functions that should be carried out by supporting personnel. The usual description mentions engineering computations and analyses, etc., but makes no mention of keeping files, procuring parts, making mod-

els, drafting, expediting and performing other similar tasks.

Meeting Conduct: A periodic review should be made to see that information is disseminated to all concerned. A specific and complete agenda should be established in advance. Meetings tie up expensive personnel and should be conducted accordingly. Executives should occasionally monitor subordinate meetings to insure value returned.

Office Arrangement: Literally miles of walking per day can be saved. In one aircraft plant, facilities that the engineer had contact with were ten-minutes away. It is not uncommon for stockrooms, blueprint facilities and laboratories to be located 300 to 500 feet away from the engineer's desk. With proper floor layout, duplicate facilities can save considerable travel time. The overhead problem affects these facilities seriously.

Supporting Personnel: Probably the most lucrative savings of the engineer's time is in relieving him of all extraneous duties.

1. *Drafting.* This time-killer can be done by personnel trained in the art.
2. *Technicians.* Trained personnel can be provided to relieve the engineer of detail shop and lab duties.
3. *Clerks.* Trained cost and schedule clerks, and component-procurement clerks can cut down the engineer's paper-work load considerably.
4. *Secretaries.* Readily available secretarial personnel can handle routine correspondence, filing and follow-up. Engineers should be trained to use dictation. Most of them will write longhand by the hour, even though it is known to be the most inefficient mode of communication.
5. *Report Writers.* Available on loan to an engineer to get out a job, writers can be of real assistance. Dictation in the rough by the engineer, with editing and art work followed by the report writer, can save considerable time.

Expected Increase of Efficiency

Relief from all these problems will not result in an engineer whose time is 100 per cent creative. Due to physiological and psychological factors, the creative part of an engineering day is considerably reduced from 100 per cent. According to some estimates, the maximum that can be expected is in the order of 30 to 35 per cent. If an engineer is burdened with routine menial tasks at periods of peak creativity, with time allocated by himself, his real value will be effectively cancelled. He will be a good clerk, but an expensive one.

There is no single, direct answer to all the problems. Proper recognition will do much to alleviate the shortage. Constructive action on the overhead and government-policy problems will have the most influential effects.

Solution of the problems encountered in increasing engineering efficiency will release engineers to perform the duties for which they are trained. There is much that can be done within the individual engineering department, however, whether or not a complete program is ever consummated.

Tips and Techniques

Correcting Sepia Prints

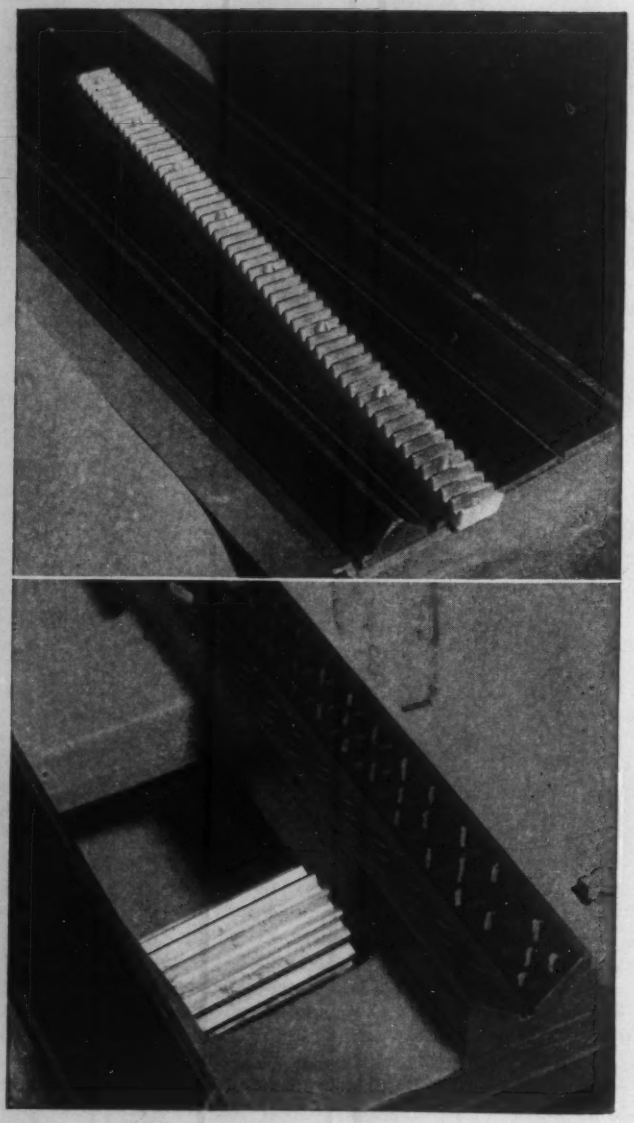
When making corrections or additions on a sepia print, place the tracing backside to the sepia paper when exposing. After development the sepia will be a mirror copy of the tracing, and if properly exposed and developed, can be read easily from the reverse side. When making corrections, all new linework and lettering is done on the reverse side (now the correct side for reading the drawing). This side of the paper, not being treated, is much easier to draw and letter on—especially the plastic-coated papers which are next to impossible to draw on — and will produce much sharper and clearer lines.

After all corrections or additions have been made, the deletions may be made on the treated side. The ensuing prints will be sharp and clear. This method also allows for additional changes to be made at a later date without making more sepias.—LEO G. DESCHENES, *Mechanical Design Electronics Div., Sylvania Electric Products Inc., Woburn, Mass.*

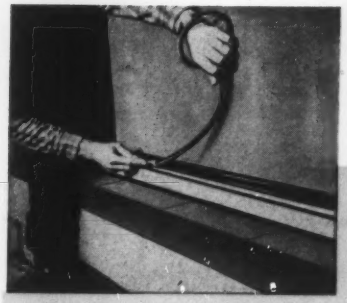
Opposite Hand Views

When left and right hand drawings are required, the process can be speeded by drawing one of the required details complete in all respects first. Instead of going through the same process and spending a lot of time measuring and laying out the same detail, this original tracing is run through the blue print machine, upside down, producing an exact duplication in the opposite hand. This print is placed under the original tracing and traced in the proper position, thus saving time in producing the required left and right hand drawings. Lettering and dimensions are added afterward. This method can also be used when large assembly drawings and layouts are required in opposite duplication.—EDWARD J. KICK, *Columbus-McKinnon Chain Corp, Tonawanda, N. Y.*

scanning the field for *ideas*

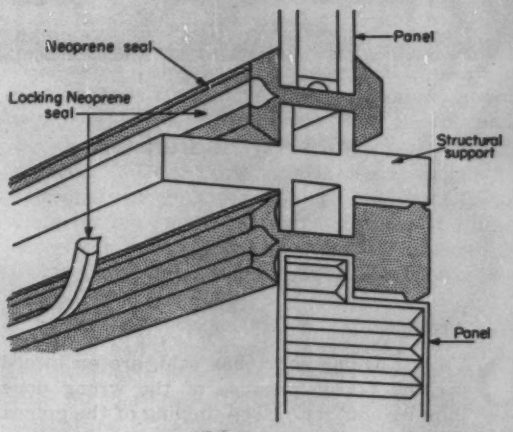


Angular gear-mounting arrangement distributes wear loads and prolongs life of meshing gear teeth. In a rack and pinion assembly designed by Harig Mfg. Co. for use in a surface grinder, the moving rack is mounted at an angle to the direction of travel. The pinion is set at a similar angle so that straight teeth may be used. Face width of the pinion is greater than that of the rack to accommodate axial displacement of the contact surfaces. During operation, the contact area between the rack and pinion moves back and forth across the length of the pinion, distributing wear loads.



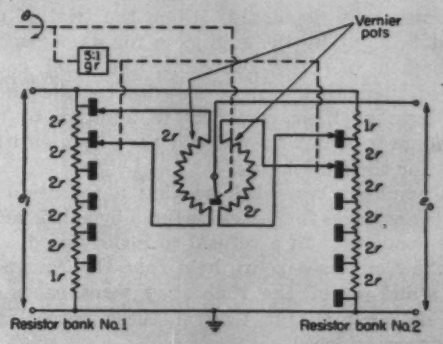
Pressed-in locking strip in two-piece panel seal design permits easy removal and replacement of panel member and assures liquid-tight joint. With seal and panel in place, locking strip is inserted, spreading outer lips to provide an effective seal around the joint.

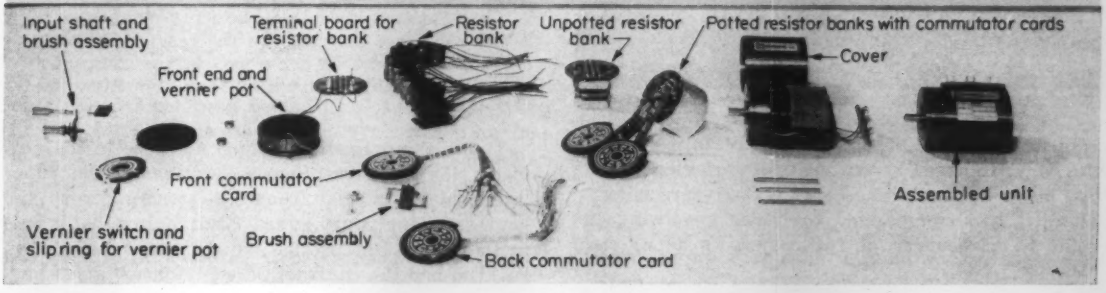
Developed by DuPont, the neoprene seal is made up of extruded sections and molded corners. After placing the seal in a supporting structure, a panel is easily fitted into it. The flared outer lips are then wedged tightly by the insertion of the extruded locking strip.



Matched bifilar resistors in multiple-turn potentiometer designed for high linearity permit overrunning rotation of control mechanism without damage. Developed by Servonics Inc., the design provides precise voltage division by taking voltage from a pair of pick-off points of one of the two resistor banks and further subdividing the voltage with a vernier pot. The action is made continuous by two voltage dividers, or banks of resistors, in series. Each vernier pot consists of a 180-degree section of a single-turn pot, designed so that the wiper shorts or bridges the two sections.

While one-half of the potentiometer interpolates through its 180 degrees of rotation, the brushes of the second bank are moving to the next pair of contacts. Thus, only one vernier potentiometer is used at any position except when the brush shorts across the two vernier windings where voltages on the two verniers are the same. Brushes move to new pick-off points along either resistor bank in sequence, giving a continuous, linear voltage output. The resistor banks are used alternately by their respective vernier pots.





A review of court decisions on recovery of damages for

Breach of Employment Contracts

By Albert Woodruff Gray
Forest Hills, N. Y.

DAMAGES, one court has said, are an award to one person because of the wrong done him by another. "The jingling of the guinea helps the hurt that honor feels."

In a Tennessee court[1] a few years ago suit had been brought by two engineers, employed under five-year contracts, who had been discharged before the end of the employment period. One had been chief engineer at an annual salary of $12,000 plus one per cent of the net profits for the first year with an increase of that amount for each of the four succeeding years. The other, as assistant at $7200 annually, was to receive a corresponding share of the net profits.

After three years the company met difficulties from a lack of adequate capital, and these men were summarily dismissed. Upon the trial of the lawsuit brought by the engineers for damages for this breach of their contracts, the trial court awarded them their unpaid salaries for the unexpired term of their contracts in addition to the percentage to which they would have been entitled except for their discharge.

The employer appealed, seeking a reduction of these percentages for losses suffered by subsidiaries of the company. In a refusal to make this deduction, the Tennessee court held that the contracts must stand as of the time they were executed, when no such charge against these percentages was even considered.

Recovery of Future Profits

In its allowance of these shares of future profits the court followed as authority a statement of the law made by that same court a few years before.[2] There it had summarized the rules governing the right to a recovery of future profits as an item of damages for the breach of a contract.

Such a recovery, that court had pointed out, had for a long time been the subject of controversy, future profits in the earlier decisions of the courts having been considered too remote or speculative to be compensated in damages. This rule, added the court, had been replaced by a rule that profits should be allowed where they could be shown with reasonable certainty under the employment contract.

The United States Supreme Court has said[3] of the right to the recovery of a percentage of profits, such as stipulated in the contracts of the engineers:

"The authorities both in the United States and England are agreed that as a general rule, subject to certain well established qualifications, the anticipated profits prevented by the breach of a contract, are not recoverable in the way of damages for such breach; but in the application of this principle the same uniformity in the decisions does not exist. The grounds upon which the general rule of excluding profits, in estimating damages, rests, are,

> (1) That in the greater number of cases such expected profits are too dependent upon numerous, uncertain and changing contingencies to constitute a definite and trustworthy measure of actual damages;
>
> (2) Because such loss of profits is ordinarily remote and not, as a matter of course the direct and immediate result of the nonfulfillment of the contract, and
>
> (3) Because most frequently the engagement to pay such loss of profits in the case of default in the performance, is not a part of the contract itself, nor can it be implied from its nature and terms.

Then, of circumstances such as those in the provision for the percentage in addition to the stipulated salary in that Tennessee contract with the engineers, the court added, "But it is equally well settled that the profits which would have been realized had the contract been performed and which

[1]References are tabulated at end of article.

have been prevented by its breach, are included in the damages to be recovered in every case where such profits are not open to the objection of uncertainty or of remoteness, or where from the express or implied terms of the contract itself, or the special circumstances under which it was made, it may be reasonably presumed that they were within the intent and mutual understanding of both parties at the time it was entered into."

Damages for Lost Benefits

A controversy of this same character brought before the Supreme Court of New Hampshire[4] concerned the discharge of an individual who had been engaged under a five-year contract. In his suit, he contended that the benefits he otherwise would have received from his employer's profit-sharing and group-insurance plans were properly included as items of damages. On the trial it was held that this employee was entitled to any amounts he would have received in addition to his salary under the contract.

When the employer appealed from the judgment, the court, in sustaining the recovery, held such additional items were elements of damage to which the employee was entitled to place him in the position he would have enjoyed had the contract been performed.

"Loss of these benefits," said the court, "was the direct consequence of the breach of the employment contract which the employer had reason to foresee as a probable result of the breach."

Limitation of Damages

Such a recovery, however, is limited to the period of the contract of hiring. In an action of this character in Tennessee[5] an employee, who had agreed to accept an annual salary of $8000 with no stipulation for a further period of employment, sought to recover benefits accruing after the expiration of that year. The court ruled: "A longer term than a year could not be introduced into the contract between the parties. To do so would require that the court fix some definite term without knowing whether the parties intended two years, five years or twenty years."

Then, of the scope of the recovery of damages here, it was added that their measure is the amount that would have been received by the employee if he had continued in the employment, less what he might earn elsewhere in the exercise of reasonable diligence.

Another item in the computation of the amounts an employee may recover if he is discharged in violation of an employment contract is the expense, which would ordinarily be incurred by him, that is payable out of his anticipated salary.

Under an employment contract before a Missouri court,[6] judgment had been awarded by the jury for the unpaid salary without consideration of future expenses chargeable against this sum. As a consequence, the appellate court pointed out in deducting such disbursements, the jury's verdict had the effect of awarding more than the amount the employee would have received.

Further, in the event of a wrongful discharge it is the duty of the employee, insofar as it is reasonably possible, to employ the time his discharge has made available to him in earning whatever wages he may, so that the obligation of his former employer will be proportionately reduced. Underlying this is the principle that a discharged employee cannot be allowed to speculate on his employer's wrongdoing and thus recover not only the salary that was assured him under his contract, but such additional sums as he might earn.

In a construction project in Philadelphia, an engineer had been employed for the duration of the work at a stipulated salary. When the work was 90 per cent completed the engineer was discharged. Deprived by this discharge of his salary for the remaining period of his contract, he sued for its recovery.[7] In its defense the employer contended that the failure of the engineer to seek other employment after his work on this project had ended barred him from a recovery.

Judgment was awarded the engineer. In the decision of the appeal by the employer the court said of this feature of the law that when an employee has been discharged, as he was in this case, without cause or sufficient excuse, he is obligated to use reasonable effort in securing other work.

Before the Federal Court recently was an appeal in a controversy of this character, from a decision by the Federal District Court in Guam.[8] Hired under a two-year contract, an employee had been discharged in the middle of the second year. The defense contended that the discharged employee had failed to reduce the amount he claimed as damages by securing other employment after his discharge.

During that period, however, the employee had worked for a building organization under an agreement for 50 per cent of the net profits as compensation. While there had been no net profits, $400 had been advanced this engineer "against anticipated profits."

In protest at the ruling of the court that the duty rested on the employer to show a failure to use reasonable diligence in finding remunerative work elsewhere, this employer complained that such a rule permitted a discharged man to gamble on the profits of any business at the expense of his former employer.

The Federal Court commented that the employer's contention was without merit, since only by reason of the employer's breach of contract

did the employee take such risks in an attempt to earn a living.

Liability of Employer

Of the damages for which an employer becomes liable in the violation of an employment agreement in the unjustified discharge of an engineer, the Court of Appeals of New York[9] State made a summary many years ago that still is authority:

"In general the parties are deemed to have contemplated only the damages and injury which the (engineers) might suffer from the nonperformance of the obligation in respect to the particular thing which is the object of it, and not such as may have been accidentally occasioned thereby in respect to other offers.

"It applies only to cases where by reason of special circumstances having no necessary connection with the contract bargain, damages are sustained which would not ordinarily flow from such breach; as where a party is prevented by the breach of one contract from availing himself of some other collateral and independent contract entered into with other parties or from performing some act in relation to his own business not necessarily connected with the agreement.

"An instance of the latter kind is where a Canon of a church by reason of nondelivery of a horse pursuant to agreement, was prevented from arriving at his residence in time to collect his tithes.

"In such cases the damages sustained are disallowed, not because they are uncertain nor because they are merely consequential or remote, but because they cannot be fairly considered as having been within the contemplation of the parties at the time of entering into the contract. Hence, the objection is removed if it is shown that the contract was entered into for the express purpose of enabling the party to fulfill his collateral agreement or perform the act supposed."

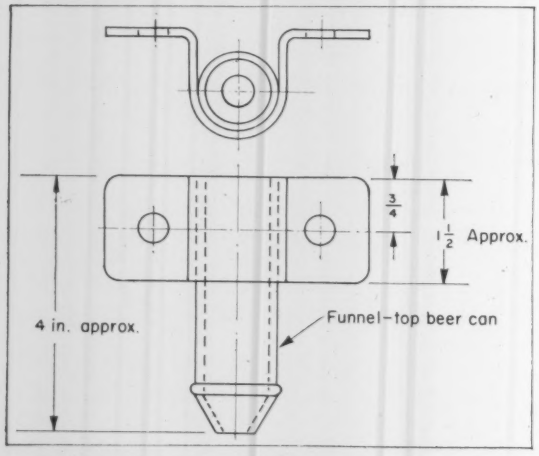
REFERENCES

1. Akers v. J. B. Sedberry Inc., 280 *S.W. 2d* 617, Tennessee.
2. Black v. Love & Amos Coal Co., 206 *S.W. 2d* 432, Tennessee.
3. Howard v. Stillwell & Bierce Mfg. Co., 139 *U.S.* 199.
4. McLaughlin v. Union Leader Corp., 116 *Atl. 2d* 489, New Hampshire.
5. Godson v. MacFadden, 39 *S.W. 2d* 287, Tennessee.
6. Dingham v. Elizabeth Arden Sales Corp., 284 *S.W. 2d* 16, Missouri.
7. Savitz v. Gallaccio, 118 *Atl. 2d* 282, Pennsylvania.
8. Fisher Construction Co. v. Lerche, 232 *Fed. 2d* 508.
9. Griffin v. Colver, 16 *New York* 489.

Tips and Techniques

Eraser Holster

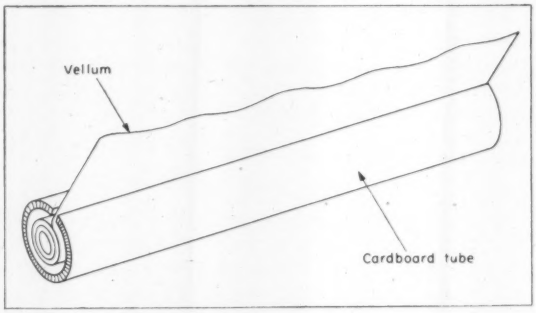
A handy device for storing an electric eraser can be easily constructed from scrap materials. An empty 12-oz. funnel-top beer can is secured and the



bottom and ½-in. of the lower edge of the sides are removed. A narrow piece of sheet metal is bent to form a strap and spot welded to the can. Two screw holes are drilled in the ends of the strap. The cut edges of the can and strap are carefully filed to remove any burrs or sharp edges, and the assembly painted.—BERNARD DOW, *design engineer, Cushman Motor Works, Lincoln, Neb.*

Protecting Layouts

To protect the rolled up ends of layouts while still on the drawing board, a cardboard tube may be used. It is cut lengthwise on a table saw, being careful to cut through one side only. The overlapping end of the layout is rolled to a diameter that will fit inside the tube. The tube is then slid over the rolled end, letting the vellum leading to



the drawing board slip through the cut on the side of the tube. This will protect the roll from crushing and dirt.—WILLIAM R. LYNCH, *South Bend, Ind.*

Power-Dividing Transmissions

Bypassing power through a divided path transmission—where an adjustable-ratio branch shunts a fixed-ratio branch—can offer advantages in size and efficiency for limited-ratio drive applications. Presented here are fundamental details, power-flow principles and performance characteristics of both two and three-path systems.

By D. L. Bedingfield
New Zealand Institution of Engineers
Wellington, New Zealand

AIM of the power-dividing or bypass transmission is to retain the advantages of a continuously adjustable drive, while reducing the losses to which such systems are subject. Power from prime mover to load passes along two separate paths in the conventional power-dividing transmission: (1) along a fixed-ratio path, usually made up of toothed gearing, and (2) through a continuously adjustable branch, usually of the friction, fluid or electromagnetic-drive type. Most mechanisms of this type depend on differential or epicyclic gearing to divide or to recombine component parts of the total power.

The price paid for the increased flexibility and efficiency of these units is greater complexity and a limitation of the range over which speed and torque ratios may be varied. Reduction in losses is due to the fact that the comparatively inefficient continuously adjustable branch is relieved by the fixed-ratio branch of part of the total power that is transferred. The extent of this relief varies from point to point over the range of ratios provided by a particular assembly. Over part of the range, the proportion of power handled by the adjustable drive may be small, and the overall efficiency correspondingly high.[1] Selection of operating ratios in this part of the range offers obvious advantages.

While two-path transmission systems have claimed most attention—that is, systems in which the adjustable-drive branch is shunted by a single, fixed-ratio channel[2]—it is possible to employ a three-path arrangement with two positive shunt paths. Some conclusions concerning such units are given here. First, however, the two-path system is briefly reviewed to establish a basis for three-path analysis.

[1]References are tabulated at end of article.

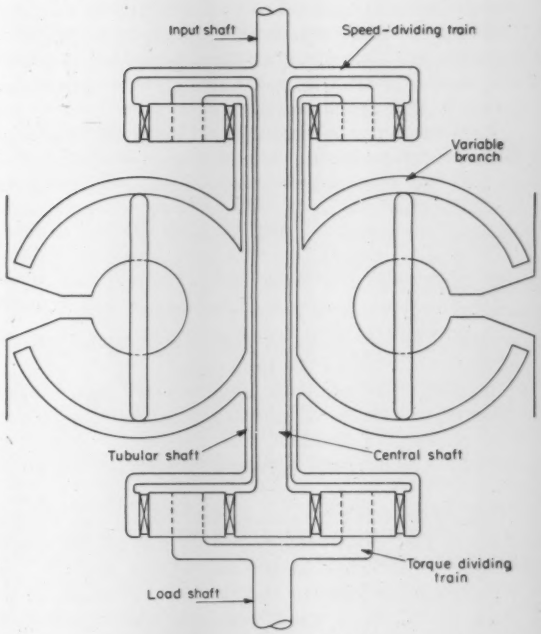


Fig. 1 — Three-path transmission with adjustable friction drive.

Two-Path Systems

Two-path systems are, in general, of two kinds: *torque-dividing* and *speed-dividing*. In the torque-dividing (or input-coupled) type, the adjustable

drive is coupled between the input shaft and the "free" or "reaction" element of an epicyclic gear train comprising the geared drive branch. The other two elements of the epicyclic train are coupled, respectively, to the input shaft and to the load shaft.

The characteristic of such systems is that input power is divided at speed ratios higher than that corresponding to the gear-train or *transition ratio* (subsequently-defined) and flows in parallel through both paths from input to load. At speed ratios lower than the transition point, a regenerative flow of power takes place—that is, power in excess of that required by the load flows through one path, and the excess returns to the input through the other path and is recirculated.

An expression for the proportion of applied power P_v transmitted through the variable drive is

$$P_v = \frac{sr - 1}{sr} \qquad (1)$$

where s is the speed ratio, *load-shaft speed* to *input speed,* and r is the ratio of the gear train, driving element to driven element with the third or reaction element stationary. Ratio r here means the transition ratio, and corresponds to the speed ratio $1/r$, where transition from regenerative to nonregenerative operation, or vice versa, takes place. No power is transmitted through the adjustable drive at this speed ratio.

Relationship between speed ratio for the adjustable drive and the resultant overall speed ratio, s, for the case where the planet carrier drives the load shaft, is

$$t = \frac{sr - 1}{r - 1} \qquad (2)$$

where t is the ratio of the output speed of the adjustable drive to the input speed.

Exploitation of both regenerative and nonregenerative phases of operation is possible only if the adjustable channel has reversible characteristics, since reversal occurs at the transition point.

Speed-Dividing Systems: In the torque-dividing system just described, a proportion of the engine torque is diverted to the adjustable channel and, through it, influences the speed of rotation of the load shaft. In a speed-dividing transmission, on the other hand, a proportion of the engine speed is considered to be diverted so as to influence the torque exerted on the load shaft. In such a geared system, the adjustable drive is coupled between the free or reaction element of the epicyclic gear train and the load shaft; the other two elements of the train are coupled to input and load shafts, respectively. Regeneration takes place at speed ratios above that corresponding to the transition ratio, and the power is divided between the two channels at speed ratios below this point.

The proportion of applied power P_v transmitted through the adjustable branch in a speed-dividing system is

$$P_v = 1 - sr \qquad (3)$$

As with the torque-dividing type, to exploit the regenerative as well as the nonregenerative phases of operation, an adjustable branch with reversible characteristics is necessary.

The relationship between the speed ratio of the variable adjustable drive and the resultant overall speed ratio, where the planet carrier drives the load shaft, is

$$t = \frac{s(r - 1)}{sr - 1} \qquad (4)$$

Several examples of speed-dividing transmission systems have been developed to the commercial production stage. One of interest is the Entz transmission, which was applied to an early automobile. Power division was accomplished electromagnetically instead of by the more common epicyclic gearing. A more recent example is found in the Napier Nomad aircraft engine, in which the output of a diesel engine is coupled to that of an auxiliary, exhaust-gas-operated turbine through an epicyclic gear system, the adjustable channel being a friction drive.

▶ Three-Path Systems

A three-path system, combining a friction-drive unit with two epicyclic gear trains, is shown in Fig. 1. The ratio of the friction-drive channel is controlled by altering the angle of the friction wheels which transmit motion from one annularly dished disk to the other. The three paths for power flow, typical of this kind of system, are apparent if an imaginary cross-section is taken through the apparatus at about the mid-point of the friction drive. The friction drive is the adjustable path; the two fixed-ratio paths are, respectively, the central shaft and the tubular shaft.

The value of r for the gear train nearest the input, because the ring gear is the driving element and sun and planet wheels are equal in size, is 1.33. The term r for this train will be designated r_1. The value of r for the gear train nearest the load shaft is 4, the sunwheel being the driving element in this case, and again equal in size to the planet wheels. The value of r for this train will be designated r_2.

In this arrangement then, a torque-dividing system (gear train nearest the load shaft) is combined with a speed-dividing system (gear at the input shaft). Output of the latter is coupled not to the load shaft, but to the ring gear of the gear train associated with the torque-dividing system. The planet-carrier of this train is coupled to the load shaft. With such an arrangement, two transition points occur in the range of speed ratios where no power is handled by the variable drive. The transition point, established primarily by the speed-dividing system, is influenced by the torque-dividing system, and this must be taken into ac-

count in determining its location.

Transition Points: If the practical limitations of the friction drive (Fig. 1) are ignored, it will be apparent that one transition point occurs when both the ring gear of the gear train nearest the load shaft (associated with the torque-dividing system) and the friction drive disk coupled to it are stationary. This point corresponds to a theoretically infinite speed reduction in the friction drive and to an overall speed ratio $1/r_2$ (0.25 here).

The other transition point occurs when the sunwheel of the other gear train (speed-dividing system) is stationary at the same time as the input disk of the friction drive. The friction drive now must give a theoretically infinite speed increase. In these circumstances, one revolution of the input shaft transmits to the load shaft (through the gear train associated with the torque-dividing system) an element of rotation $1/r_2$. Through the other gear train, one input-shaft revolution is transmitted as an element of rotation $1/r_1$. This is modified by its application to the load shaft through a ratio equal to $r_2/(r_2 - 1)$. The total rotation of the load shaft for one turn of the input shaft is then

$$\frac{1}{r_2} + \frac{(1/r_1)(r_2 - 1)}{r_2} \qquad (5)$$

or

$$\frac{r_1 + r_2 - 1}{r_1 r_2} \qquad (6)$$

This is the speed ratio corresponding to the second or upper transition point (0.81 in the present instance).

With speed ratios other than those corresponding to the two transition points, the speed-dividing system incorporating the variable drive is to be regarded as one channel of a torque-dividing system. The other or fixed-ratio channel terminates in the sunwheel of the torque-dividing train. The expression

$$\frac{sr_2 - 1}{sr_2} \qquad (7)$$

therefore, in accordance with a preceding statement, indicates the proportion of input power which the speed-dividing system is required to handle. As before, s is the overall speed ratio.

In Fig. 2, curve A shows this proportion for the assembly sketched in Fig. 1. Typically, it is an arc of a rectangular hyperbola.

Of the power traversing the speed-dividing system, the proportion transmitted by the adjustable drive has been shown (Equation 3) to be $1 - sr_1$, where s is the ratio *output speed* to *input speed* of the speed-dividing system. Before this factor can be combined with that relating to the torque-dividing system, it must be modified by relating it to the overall speed range, instead of to that existing within the speed-dividing system considered as a separate entity. The speed-dividing characteristics for the unit in Fig. 1 (before modification) is shown as the dashed line B in Fig. 2.

For an overall speed ratio s, the ring gear-wheel of the torque-dividing system, rotated by the speed-dividing system, is required to provide only the remaining motion of the planet-carrier over and above that supplied by the sunwheel of the torque-dividing train. Since the contribution of the sunwheel is $1/r_2$, the remainder is $s - 1/r_2$. The ratio of this remainder to the fraction of load-shaft rotation represented by the interval between the two transition points is a measure of the relief given the adjustable drive by the speed-dividing gear train shunting it. That fraction of rotation was earlier defined as

$$\frac{(1/r_1)(r_2 - 1)}{r_2}$$

Hence the expression $1 - sr_1$ becomes

$$1 - \frac{r_2(s - 1/r_2)}{(1/r_1)(r_2 - 1)} \qquad (8)$$

or (see curve C, Fig. 2)

$$1 - \frac{r_1 r_2(s - 1/r_2)}{(r_2 - 1)} \qquad (9)$$

This modification having been made, expressions for the torque-dividing and speed-dividing systems may be combined. Related directly to overall speed ratio, this expression gives the proportion of input

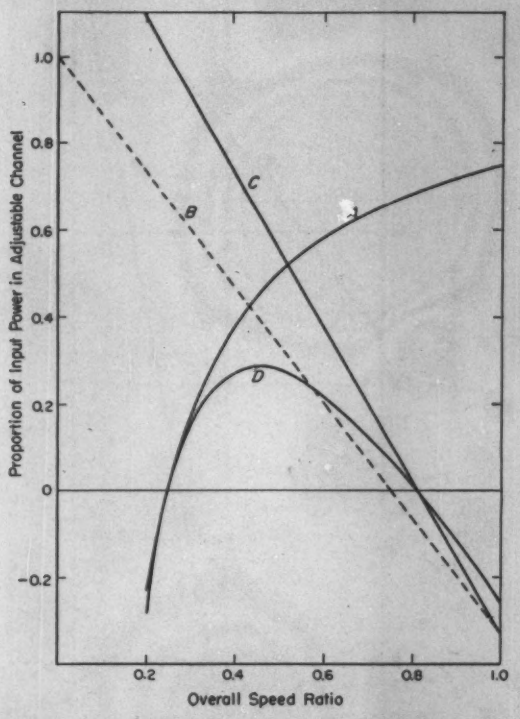


Fig. 2—Power-dividing characteristics of three-path transmissions.

power ideally transmitted by the adjustable drive channel. The proportion is

$$\left\{ [sr_2 - 1][1/sr_2] \right\} \times \left\{ 1 - \frac{r_1 r_2 [s - (1/r_2)]}{r_2 - 1} \right\} \quad (10)$$

and, for the assembly in Fig. 1, is shown as curve *D* in Fig. 2. The characteristic is an arc of a hyperbola. Operation below the zero-power axis is regenerative, and the fact that the friction drive would prohibit operation in the regenerative range has been ignored.

Fig. 2 shows how the modified speed-dividing characteristic *C* is quickly obtained from the unmodified characteristic *B* by extending the latter if necessary to meet the ordinate corresponding to synchronism. The modified characteristic is then drawn from this point on the ordinate to a point corresponding to unity power ratio and speed ratio of $1/r_2$. The upper transition point

$$\frac{r_1 + r_2 - 1}{r_1 r_2} \quad (11)$$

is disclosed by the intersection of this line with the zero power axis.

Comparison of Systems

From the background established here for the different types of power-dividing transmissions, it is possible to make a theoretical comparison of characteristics. The peak proportion of input power, ideally traversing the adjustable drive for selected ranges of speed and torque conversion, forms a logical basis on which to compare the units. Practical factors to which attention will be directed must be considered before any conclusions can be formed.

Ideally, for each type of power-dividing transmission there is a relationship between the peak proportion of input power traversing the adjustable drive and the ratio, *maximum torque* to *minimum torque*. In Fig. 3 characteristic *A* gives the power relationship for two-path systems using regeneration. Curve *B* relates to a three-path system without regeneration, implying operation confined to the range between the two transition points. Curve *C* is for a three-path system using one of the two available regenerative phases. The effect of using both is shown by curve *D*. The limit of regenerative operation is the point where the proportion of power transmitted by the variable drive equals the maximum attained during nonregenerative operation.

The extent to which the power transmitted by the adjustable drive can ideally be reduced by the shunt path conveys an unduly optimistic impression of the advantage to be gained by this means. From a practical point of view, to utilize the en-

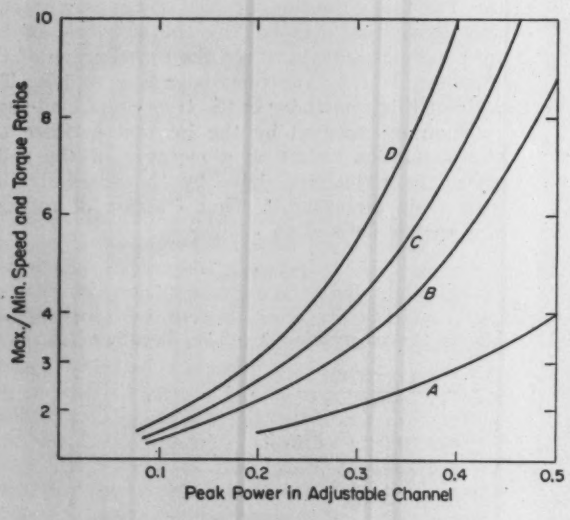


Fig. 3—Comparision of two and three-path systems.

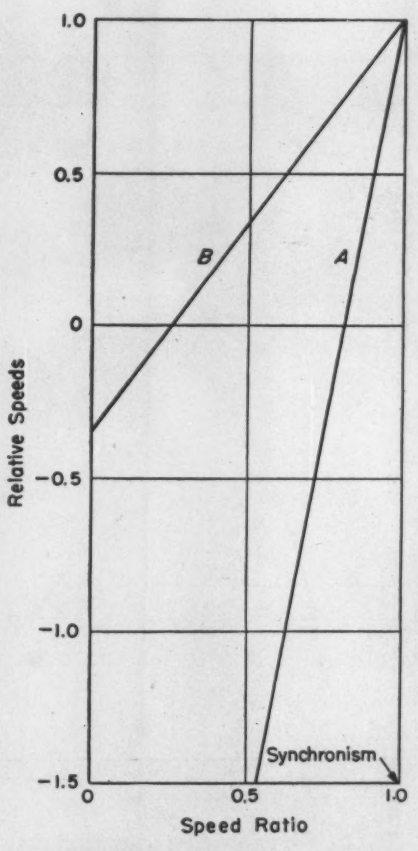


Fig. 4—Relative component speeds.

tire useful part of both regenerative and nonregenerative phases of operation calls for an adjustable-drive mechanism of great flexibility. A combination of electrical machines is the least restrictive from this point of view. Other mechanisms limit operation to only part of the range theoretically available. Further, load reaction differing from engine torque is necessarily transmitted to the supporting structure through the adjustable-drive mechanism. Hence, although the power transmitted by this may be substantially reduced, it must still be capable of developing the required reaction forces. As a final point, high relative component speeds, a function of the ratios selected for the epicyclic gear trains, limit freedom of choice for the latter.

The last point is illustrated by Fig. 4, which, for the Fig. 1 assembly, shows the speed (relative to input speed) of the driving side (A) and the driven side (B) of the friction drive. Speed relationships, in any instance, may be examined by a diagram of this type, where lines from the point corresponding to synchronism at unity power ratio are extended through the transition points on the zero-power axis to the limits of intended operation. Since the speed of each component relative to input speed is indicated, there are also revealed the speeds of components relative to each other; that is, the instantaneous ratio of the constituent variable drive for any overall speed ratio. Also revealed is the range of speed ratios over which the variable drive is required to reverse the direction of rotation applied to it.

Three-Path Working Model

The power-transmission relationships described in preceding sections were examined with the aid of mechanisms using friction drive for the adjustable path. A better approach to an actual "working" transmission was sought as a means of observing the operation of a three-path unit. This requirement was satisfied by using for the variable adjustable drive a pair of small electrical machines. Originally, these were shunt-wound motors, but in the experimental unit the fields were excited by a storage battery.

Electromagnetic Coupling: To eliminate one of the two otherwise necessary gear trains, electromagnetic division of power like that in the Entz speed-dividing transmission was employed. This arrangement also eliminates difficulties from high relative component speeds. In the Entz transmission, the input shaft rotates the field of a generator whose armature is coupled to the load shaft. The armature of an electric motor fed from the generator output is also coupled to the load shaft. Magnetic drag between the generator field and the armature transmits any load reaction to the engine supports that is equivalent to the torque developed by the engine. The remaining reaction causes relative movement between the generator field and the armature, thereby generating an e.m.f. and feeding current to the motor. This current augments the torque exerted on the load shaft by the magnetic drag of the generator.

Third Path: The Entz transmission provides two paths for transmission of power: one comprises the magnetic drag between the generator field and the armature; the second is the electrical circuit connecting the two machines. In the model a third path was provided by a differential gear train fabricated from small bevel gears. Two transition points occur: (1) at a speed ratio of 0.5 (be-

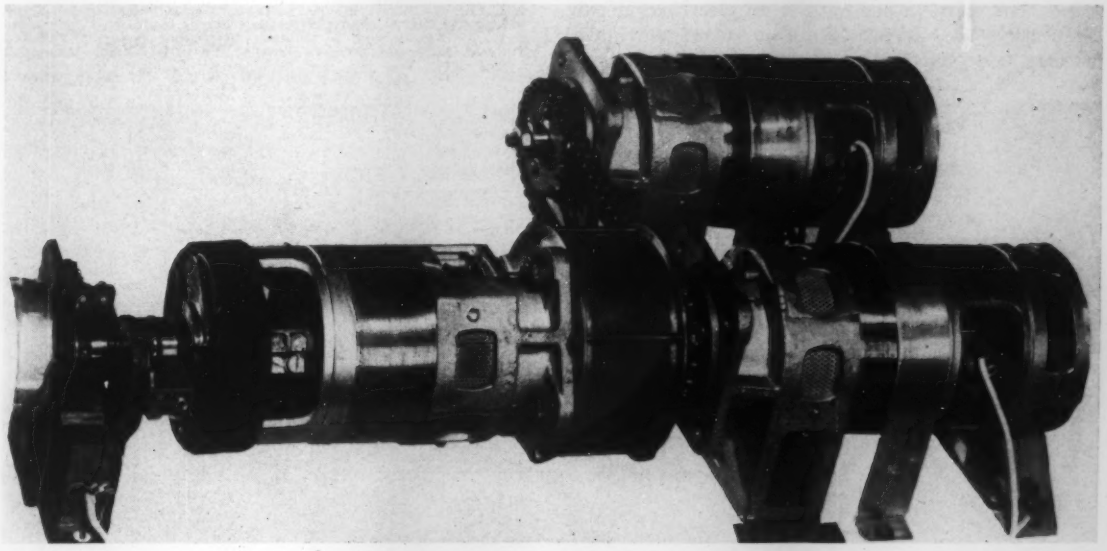


Fig. 5—Model of three-path transmission.

cause the differential gear train provides a value of $r_2 = 2$), and (2) at synchronism (from the electromagnetic division of power between two of the power paths). The range of torque ratios with nonregenerative operation is therefore 2. The corresponding peak proportion of power transmitted electrically is, ideally, 0.175.

With both regenerative phases of operation exploited to give a similar peak proportion of power converted, the range of operation is extended over speed ratios from 0.43 to 1.15, corresponding to a range of torque ratios of nearly 2.7.

In Fig. 5, the speed-dividing machine called Machine 1 (the other is Machine 2), carries shaft extensions at either end. One end carries slip rings; the other encloses the differential gear train. This machine is rotated bodily by a motor (not shown) coupled to the slip ring end and, hence, the slip rings are necessary for electrical connections. The third machine in the background, driven from the load shaft by a chain-and-sprocket drive, is not part of the transmission but provides an adjustable load by generating current which is dissipated through an adjustable resistor.

Fig. 6 shows Machine 1 in outline with longitudinal sections of the slip ring assembly (left) and the differential gear train (right). The first of the three paths for the flow of power is through the body of the machine and the differential housing, then to the side bevel of the differential gear train remote from the machine. The side bevel adjacent to the machine, forming the second power path, is influenced directly by the magnetic drag between field and armature of the machine, since it is bushed tightly on the armature shaft. The armature of Machine 2 also influences the side bevel adjacent to Machine 1. Its shaft is coupled to the armature of Machine 1 by a tubular shaft, part of which serves as the inner bush for that bevel. The third power path is an electrical circuit connecting the armatures of the two machines. Electrical power is transformed from mechanical power by one and is transmitted to the other where it is reconverted into mechanical power. This is the adjustable path, the power in which suffers loss from the double conversion.

Combining the Power: The second and third power paths are combined to give a common output, since the armatures of the two machines are mechanically coupled. These two paths are recombined with the first power path by the combined influence of the two side bevels on the pinion-carrier of the differential gear train. The pinion-carrier is linked to the chain sprocket which drives the load by a short tubular load shaft. The shaft rotates between the outer surface of the tubular shaft coupling the two armatures and the inner surface of the side bevel remote from Machine 1.

Control of the ratio of the model transmission is by field regulation. Near synchronism, the field of Machine 2 is left unexcited, and that of Machine 1 is fully excited. The latter operates virtually as an electric coupling. Near the transition speed ratio of 0.5, it is Machine 1 that is unexcited, while Machine 2, now fully excited, brakes the armatures and the coupled side bevel nearly to rest. Between these two points, control is by differential regulation, the one field being strengthened while the other is weakened. To obtain speed ratios lower than the transition-speed ratio of 0.5, Machine 1 is partially excited in reverse so that it accepts current generated by and fed back from Machine 2, which is fully excited. The direction of armature rotation is reversed as compared with operation at higher speed ratios.

To obtain speed ratios above synchronism, Machine 2 is partially excited in reverse. Current is generated and fed back to Machine 1, which is fully excited. This causes its armature to rotate relative to and faster than the field. Since the latter rotates at synchronous speed, the armature and the load shaft rotate faster than synchronous speed.

REFERENCES
1. L. A. Graham—"Planetary Transmissions," MACHINE DESIGN, Vol. 18, No. 11, Nov. 1946, Page 115.
2. L. A. Graham and S. Gilman—"Bypassing Power in Variable-Speed Drives," MACHINE DESIGN, Vol. 24, No. 5, May 1952, Page 127.

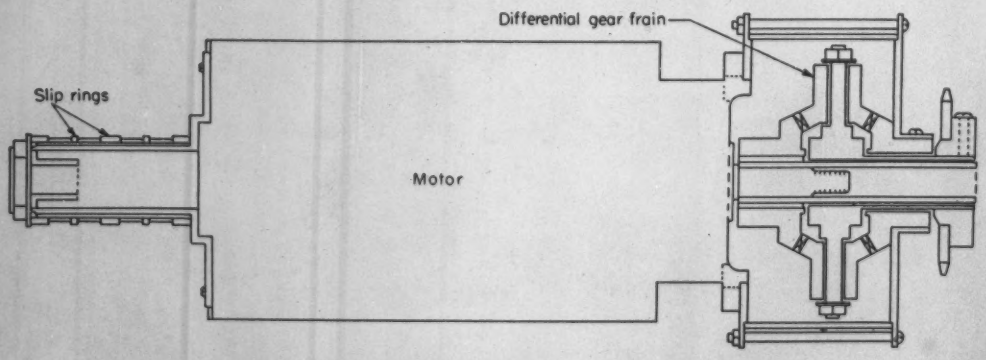


Fig. 6—Adapting electric motor for model.

Quantitative design of

SERVO SYSTEMS

by frequency-response methods

Part 2—Logarithmic Response Curves

By J. M. Nightingale
Manchester, England

APPROXIMATION methods are quite useful and timesaving in the design of modifying networks for improving the performance of servo systems. Recent articles in this group[1-14] have dealt with the fundamentals of such networks.

Logarithmic response curves — so-called Bode plots—provide a convenient method for choosing suitable parameters for networks put in cascade with the forward-path elements to improve performance. Some typical passive and active compensating networks are shown in Fig. 7 together with asymptotic approximations to their response curves. Some typical uses will now be discussed briefly.

A first-order system with adequate stability margins has loop response curves shown in Fig. 8*a*. Suppose now that it is required to reduce the steady position error by increasing K, maintaining the same stability margins. One way of doing this is by means of the network shown in Fig. 7*b*. The characteristics of this network are shown dotted in Fig. 8*a*. Since the network is in tandem with the other components, it is merely necessary to add these components to those of the original system. Curves for the modified system are shown in Fig. 8*b*.

The gain can now be increased by 20 $\log_{10} a$ decibels in order to restore the previous gain margin. This in effect means that the scalar gain can be increased a times, thus reducing the steady-state error $1/a$ times. Although it is desirable, therefore, to increase a on this ground, increasing a also increases the phase lag introduced by the network. Since there is an initial lag of 90 deg in first-order systems, this additional phase lag should not be greater than about 45 deg. This means that $a = 5.8$, allowing a 15-db lift to the

[1]References are tabulated at end of article.

About the Author . . .

Principally through this continuing program of articles on servo systems, J. M. Nightingale has become widely known as an expert on control-system design.

A native of the county of Devonshire, England, Mr. Nightingale began his industrial experience in 1944 as an apprentice in general engineering with Frandor Engineering Co. Next came a period of industrial research with Tannoy Products on electronic amplifiers and acoustic equipment.

In 1949 Mr. Nightingale entered the control-system field with British Messier Ltd., doing development work on aircraft and missile-control systems. Initially his work covered many aspects of control-system design. As control-system development expanded, he headed up the analytical dynamics team.

On a Whitworth Scholarship, Mr. Nightingale attended Manchester University, receiving his B. Sc. degree in 1955, with First Class Honors, in electrical engineering. At present he is working toward his doctorate at Manchester University on a Whitworth Fellowship, only two of which are awarded competitively in the United Kingdom each year.

Currently, in addition to some consulting work and research in self-optimizing control systems, he holds a lecturing appointment at Manchester University.

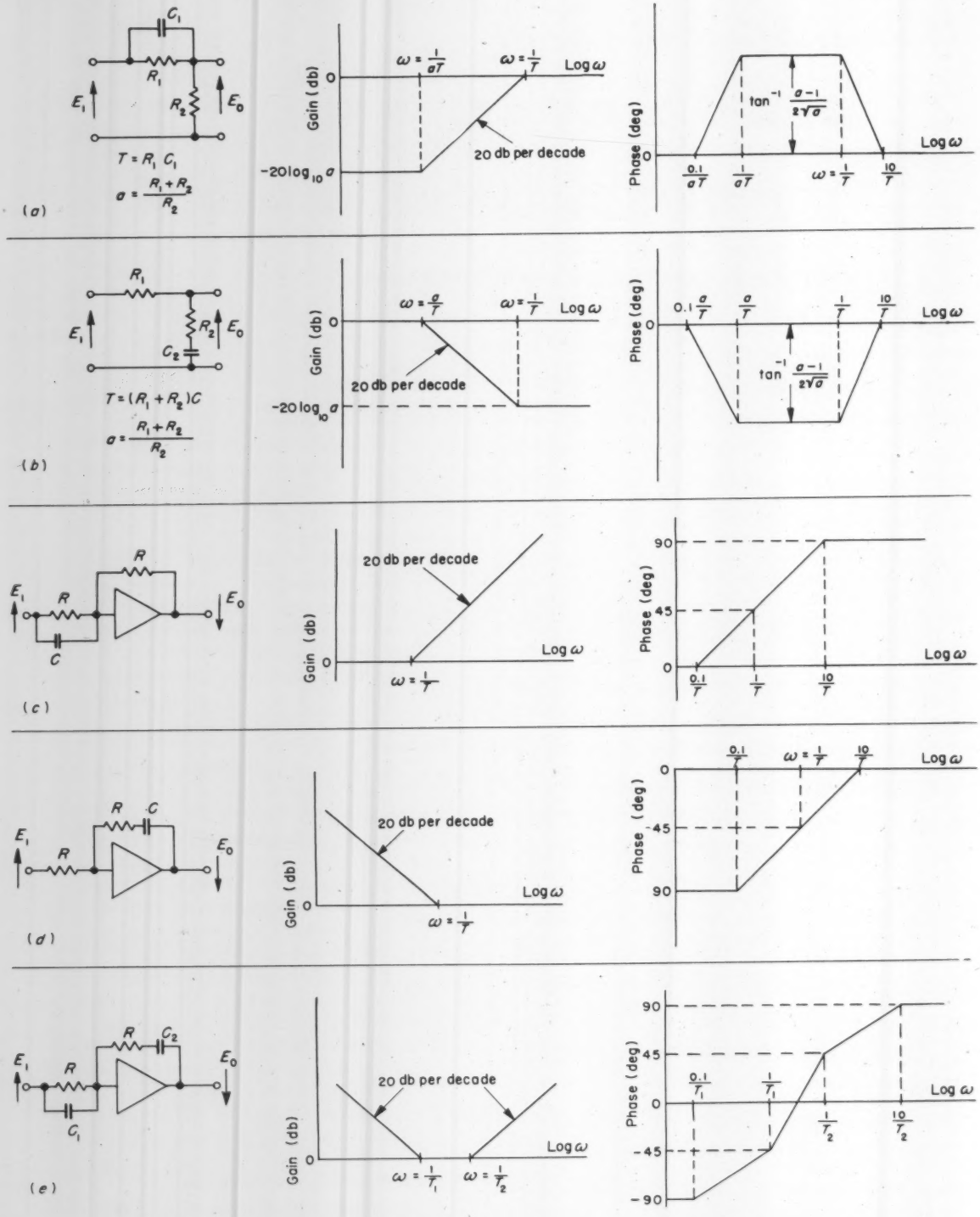


Fig. 7 — Useful networks together with straight-line approximations of their gain and phase curves: (*a*) a passive approximation to a "proportional-plus-derivative" network; (*b*) passive "proportional-plus-integral" network; (*c* and *d*) active networks which give the desired characteristics much more closely if very high-gain amplifiers are used; (*e*) an active "proportional-derivative - plus - integral" network.

gain curve. The time constant T of the network must be chosen so that phase changes occur well below the gain crossover frequency ω_c. However, the frequency range in which gain is effectively increased should be as wide as possible to improve accuracy; hence, a compromise must be accepted. This may be achieved by making $10/T$ somewhat less than ω_c. Thus a and T can be chosen.

Note that this network is a passive approximation to the active "proportional-plus-integral" network of Fig. 7*c*. This latter network would make the servo of the second order (slope of -40 db per decade at low frequencies), thus reducing the steady-state error to zero. See dotted curve of Fig. 8*b*.

As a second example consider the problem of improving both bandwith and scalar gain by using a passive phase advancer, Fig. 7*a*. Loop and network characteristics are shown dotted in Fig. 9, while the full lines show the modified characteristics. The frequency of maximum phase advance of the network $\omega = \sqrt{(a)}/T$ is chosen approximately equal to ω_p, the frequency at which $\psi = -180$ deg in the original system. Therefore, for the modified system the phase angle reaches -180 deg at a higher frequency ω_p'. The gain curve is modified as shown with a constant attenuation of $20 \log_{10} a$ decibels at low frequencies. By shifting the modified gain curve up by A' decibels, Fig 9, the gain margin again becomes 10 decibels, while the phase margin is again satisfactory. In order that both gain and phase margins shall be compatible it is usually recommended that the slope of the gain curve shall be about -20 db per decade near the gain crossover frequency.

An approximate measure of the bandwidth of the overall amplitude response and hence of the sensitivity is given by ω_p. Obviously these factors have been greatly improved in this example. Also the net increase in the scalar gain ($A' - 20 \log_{10} a$) decibels shows that the steady-state errors have been reduced. Once again choice of a is a compro-

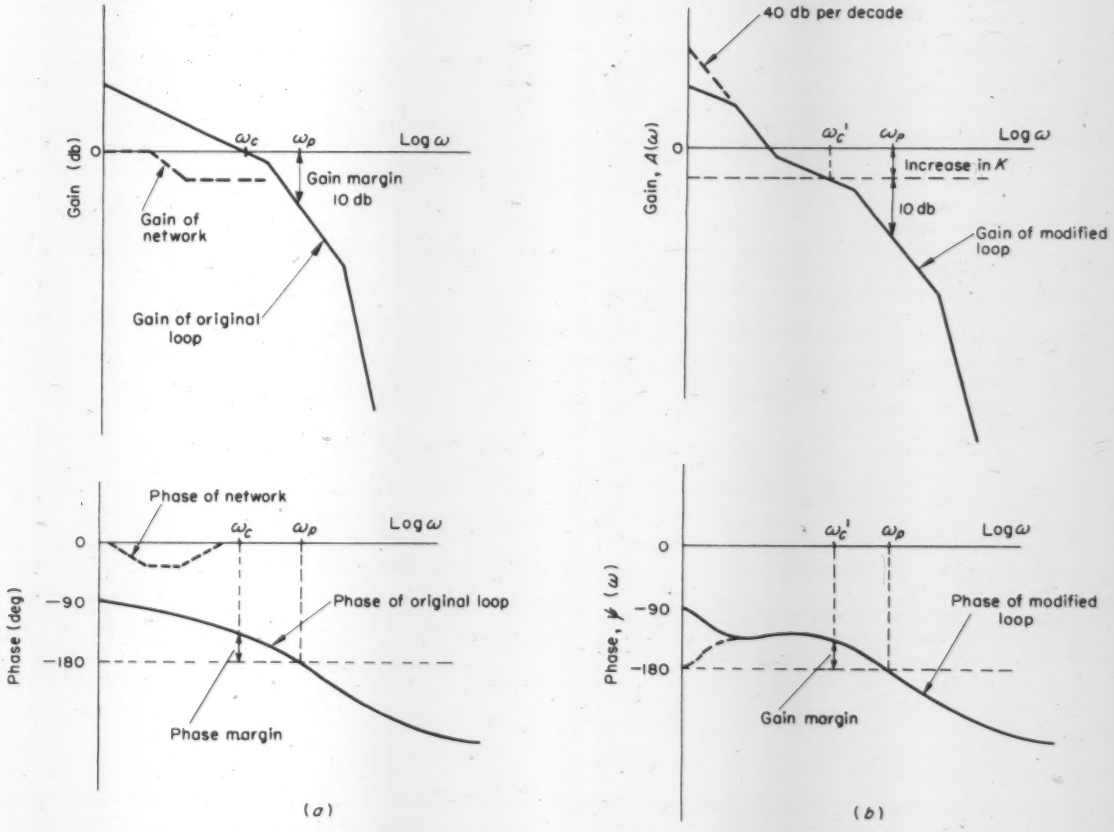
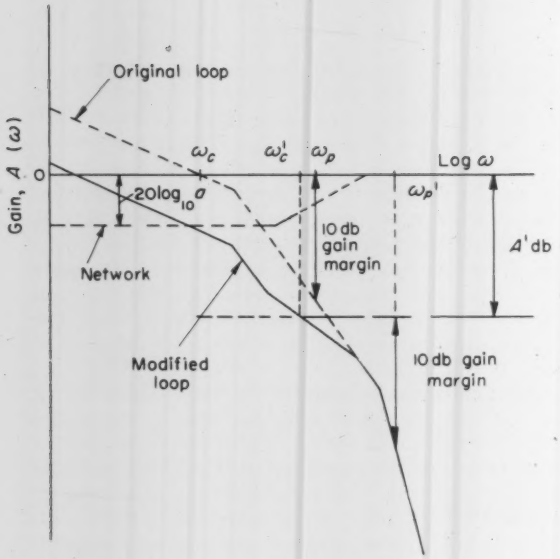


Fig. 8—At *a*, original loop characteristic and network characteristic. These are added at *b* to give the modified loop curves. It will be seen that the scalar gain can be increased while maintaining adequate gain margins. Dotted curve shows how an ideal "proportional-plus-integral" network would modify the characteristics of the original loop.



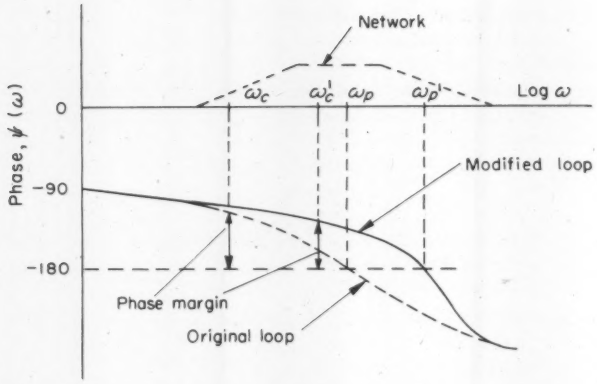
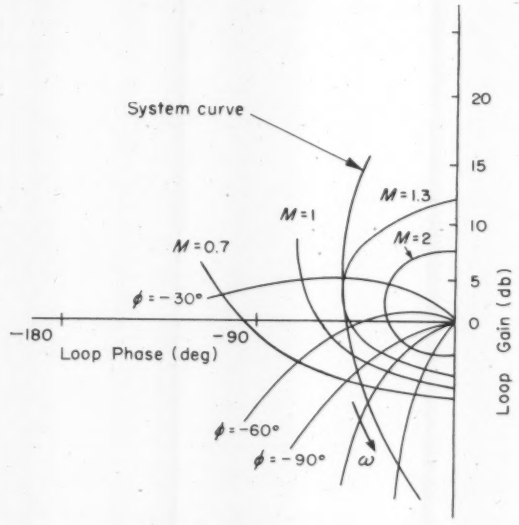


Fig. 9—Effect of a phase-lead network, showing how the frequency at which 180-deg phase shift occurs can be delayed. It is then possible to increase K to restore original stability margins. This results in increase of bandwidth and a net increase in the scalar gain. Method is not always successful when there are lightly damped quadratic lags in the critical-frequency range.

Nomenclature

$A(\omega)$ = Loop gain in decibels
$A_1(\omega), \ldots$ = Gains in decibels
a = Constant
e = Error
H = Constant
K = Scalar gain constant
k = Constant
$M(\omega)$ = Overall amplitude ratio
$N(\omega)$ = Loop amplitude ratio
$N_1(\omega), \ldots$ = Amplitude ratios
n = Constant
$p_1, \ldots$ = Poles
r = Order of servo
s = Laplace operator
T = Time constant
$T_1, \ldots$ = Time constants
u = Nondimensional frequency variable
x = Nondimensional frequency
$Y(s)$ = Transfer function
$Y_o(s)$ = Loop transfer function
$Y_o(j\omega)$ = Loop harmonic response function
$Y(s)$ = Transfer function
$z_1, \ldots$ = Zeros
$\psi(\omega)$ = Loop phase angle
$\psi_1(\omega)$ = Phase angles
θ_o, θ_i = Output and input
ω = Frequency variable
$\phi(\omega)$ = Overall phase
τ = Time delay
ζ = Damping ratio

Fig. 10—Loop gain versus loop phase, directly plotted. This is probably easier to do than to make a Nyquist plot from the gain-phase charts. Curves showing overall amplitude ratio and phase can be superposed. A typical system plot is shown with its gain level adjusted until maximum overall amplification is 1.3.



mise. Large a means large phase-advance angles but also means a large low-frequency attenuation. Suitable values for a lie between 5 and 20. Table 1 lists the corresponding maximum phase-advance angles and low-frequency attenuation for various values of a.

Where the loop transfer function of a first-order system contains a quadratic lag whose phase component contributes significantly to the loop phase near ω_p, the damping ratio ζ should be high ($\zeta > 0.6$). Otherwise the rapid change of phase with frequency will mean that phase-advance networks giving less than 90 deg phase advance can offer little in improving bandwidth or scalar gain.

Since the addition of modifying networks in tandem involves only simple additions to Bode

plots, it is an easy matter to construct straight-line approximations to compensating characteristics where required. These may be quite general rather than specific types. It then becomes a question of realizing networks to yield the desired characteristics. This is not too difficult using straight-line approximations since the transfer function of the modifying network will then be made up entirely of terms of the form $1 + Ts$.

Table 1—Phase-Advance Angles vs. Low-Freqency Attenuation

	Constant, a					
	1.3	1.7	3.0	5.8	14	57.7
$20 \log_{10} a$ (decibels)	2.28	4.60	9.54	15.30	22.90	35.2
ψ_{max} (deg)	7.5	15	30	45	60	75

One word of warning is necessary. Bode[15] has shown that for most practical networks, gain and phase characteristics are closely related and cannot be adjusted independently. This places some restraint on the approach to compensation. This point will be further discussed in Part 3 of this article.

Having completed Bode plots for system, and having satisfied the necessary stability margins, one should next check on the overall characteristics of the system. This can be done by plotting the Nyquist plot from the Bode plot, and then using curves of constant M and ϕ, Reference 4. It is, however, simpler to plot A against ψ directly, with ω as a parameter. Then, contours of constant M and ϕ are transformed to the curves shown in Fig. 10. A typical system response is plotted with K adjusted so that the maximum overall amplitude ratio is 1.3. Final adjustment to K can be made simply by shifting the locus vertically until it just touches the $M = 1.3$ contour.

REFERENCES

This article is the fifteenth in a co-ordinated group by J. M. Nightingale on servo systems. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" ..... May 17, 1956
2. "Servo Mathematics" ..... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" .. July 26, 1956
4. "Evaluating Servo System Performance—Part 2" .. Aug. 9, 1956
5. "Analyzing Servo Systems" ..... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" ..... Nov. 29, 1956
7. "Hydraulic Servo Components—Part 2" ..... Dec. 13, 1956
8. "Hydraulic Servo Components—Part 3" ..... Dec. 27, 1956
9. "Hydraulic Servos—Part 1" ..... Feb. 21, 1957
10. "Hydraulic Servos—Part 2" ..... Mar. 7, 1957
11. "Hydraulic Servos—Part 3" ..... Mar. 21, 1957
12. "Improving Servo System Performance—Part 1" .. May 30, 1957
13. "Improving Servo System Performance—Part 2" .. June 13, 1957
14. "Quantitative Design of Servo Systems—Part 1" .. July 11, 1957

Another reference mentioned in the current article is:

15. H. Bode—*Network Analysis and Feedback Amplifier Design*, Van Nostrand, New York, 1945.

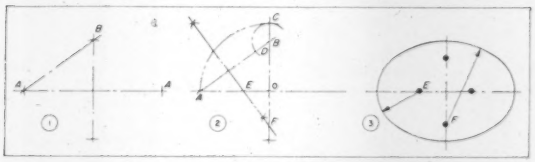
REPRINTS

Articles listed above by J. M. Nightingale are now available in reprint form. Articles 1 to 5 are contained in Volume 1 (32 pages) and articles 6 to 11 in Volume 2 (32 pages) of "Hydraulic Servo Fundamentals." The volumes are available at $1.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Tips and Techniques

Constructing an Ellipse

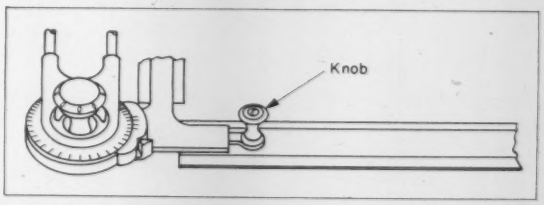
In drafting, an ellipse can be drawn readily without the use of a French curve with sufficient accuracy for practical purposes. On perpendicular lines, the four points are located that are the ends of the major and minor axes and determine the size and relative shape of the ellipse. A line is



drawn from one end of the major axis, A, to one end of the minor axis, B. An arc with a radius of one-half the major axis, AO, is struck on the line of the minor axis, creating point C. Using BC as a radius, point D is located on line AB. Line segment AD is then bisected with a perpendicular that is extended to form points E and F. These points are centers for arcs that produce half the outline of an ellipse. Two similar points located on the other side enable construction of the complete ellipse.—THOMAS ROSTRON, *Schramm Inc., West Chester, Pa.*

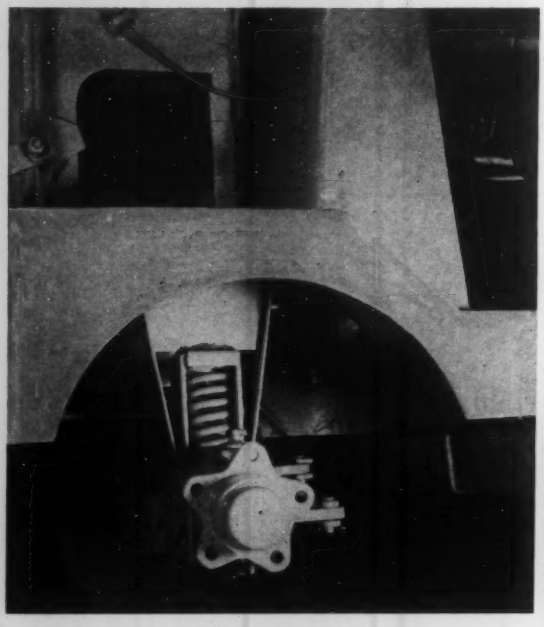
Drafting Machine Aid

Horizontal positioning of the drafting machine can be speeded by adding a knob to the horizontal scale. This permits closer control of scale positioning and speeds precision drafting. One of the

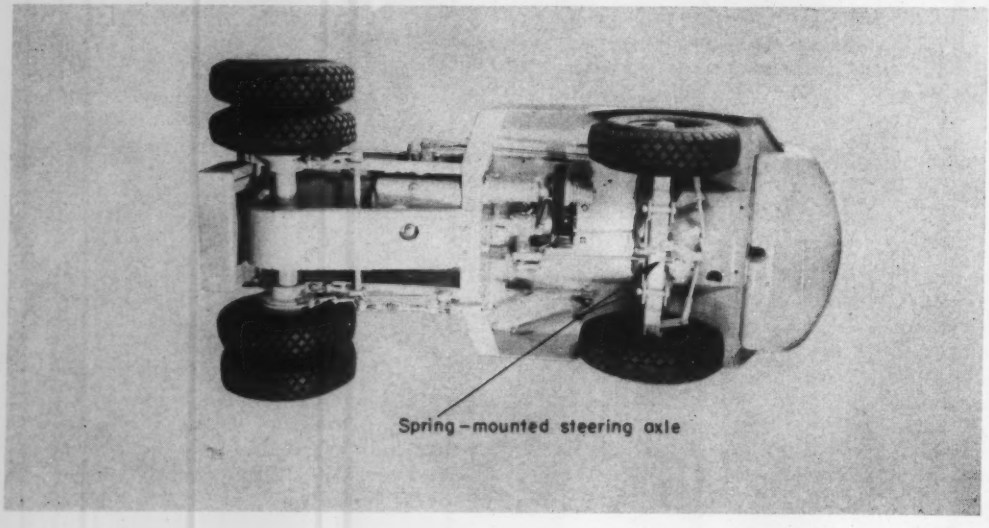


screws that holds the locking wedge to the scale is removed and replaced with a longer one. Replacement screw length depends upon the size knob selected. — LEE WELCH, *Chisholm-Ryder Co. Inc., Niagara Falls, N. Y.*

Spring-Mounted Steering Axle Design



The steering axle on the R-15 Moto-Bug is mounted on two heavy-duty coil springs to cushion the operator and vehicle from load and travel shocks. The king-pin assemblies are securely welded to each end of the steering axle in this materials-handling truck which is manufactured by the Kwik-Mix Co. The construction technique offers a rugged design for heavy duty service.



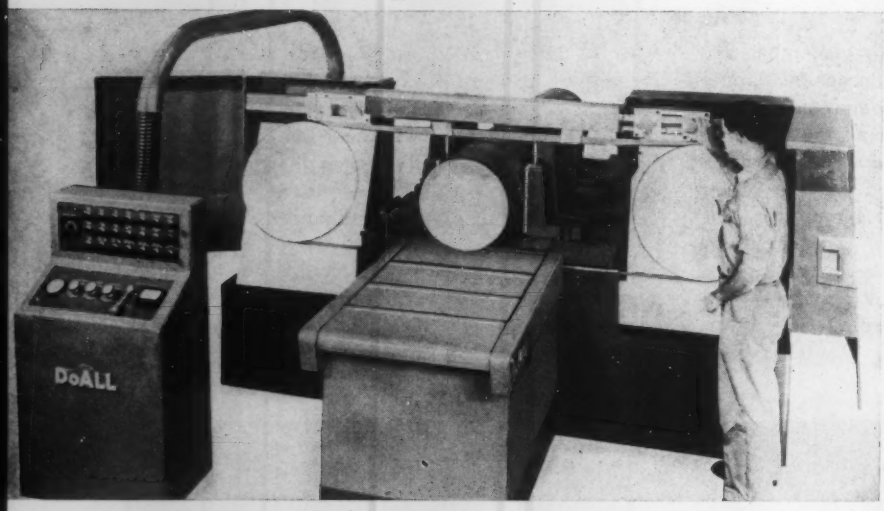
Multiple-Function Buzzer Signal System

A "heads-up" warning buzzer, re-styled input and output controls, and a foldaway microphone hanger are among new features of the Comptometer Commander magnetic-belt dictation machine made by Comptometer Corp. If dictating is attempted without lowering the recording head on the Mylar magnetic belt, a buzzer sounds as a reminder. The buzzer also begins to operate 10 seconds before the end of the belt is reached; the buzzing sound is intermittent at first, and then gradually becomes continuous when the recording time is up.

A knurled output control knob, numbered from 0 to 10, allows the operator or the transcriber to set output volume at the desired level each time, without searching. Similarly, a concealed input control knob on the bottom of the machine provides a compensating adjustment for special dictating problems and conditions, such as room noise level and speaking distance and volume.

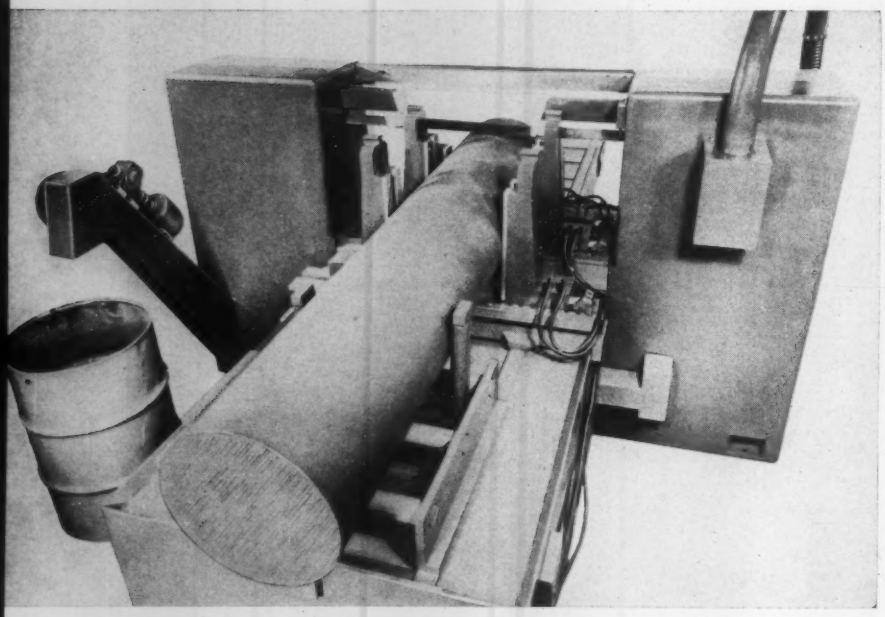
A three-position switch and an indexing button on the remote-control microphone permit the operator to dictate, reverse to review, listen, erase, and mark the end of a letter without touching the machine.

Automatic Hydraulic Speed,



Control system for the new model 24 DoAll power saw is designed to permit three methods of machine operation: completely automatic, crop-automatic and manual. The crop-automatic position permits the operator to make a squaring cut before starting automatic sawing operations. This heavy-duty metal sawing machine has a 24 by 24-in. capacity.

Rotational drive power for the pump that turns the 2-in. wide saw band is obtained from a 10-hp electric motor. This same motor also drives another hydraulic pump that provides the power for the two head-raising cylinders, band-tensioning cylinder, the main machine vise and the outboard vise, the hydraulic motors that drive the conveyor rollers, and the variable-speed control for the main pump.



The hydraulic motor, which drives the saw blade, is connected by flexible lines to a variable-displacement hydraulic pump. The hydraulic motor drives the band wheel through a gear reduction, providing infinitely variable speeds within its range.

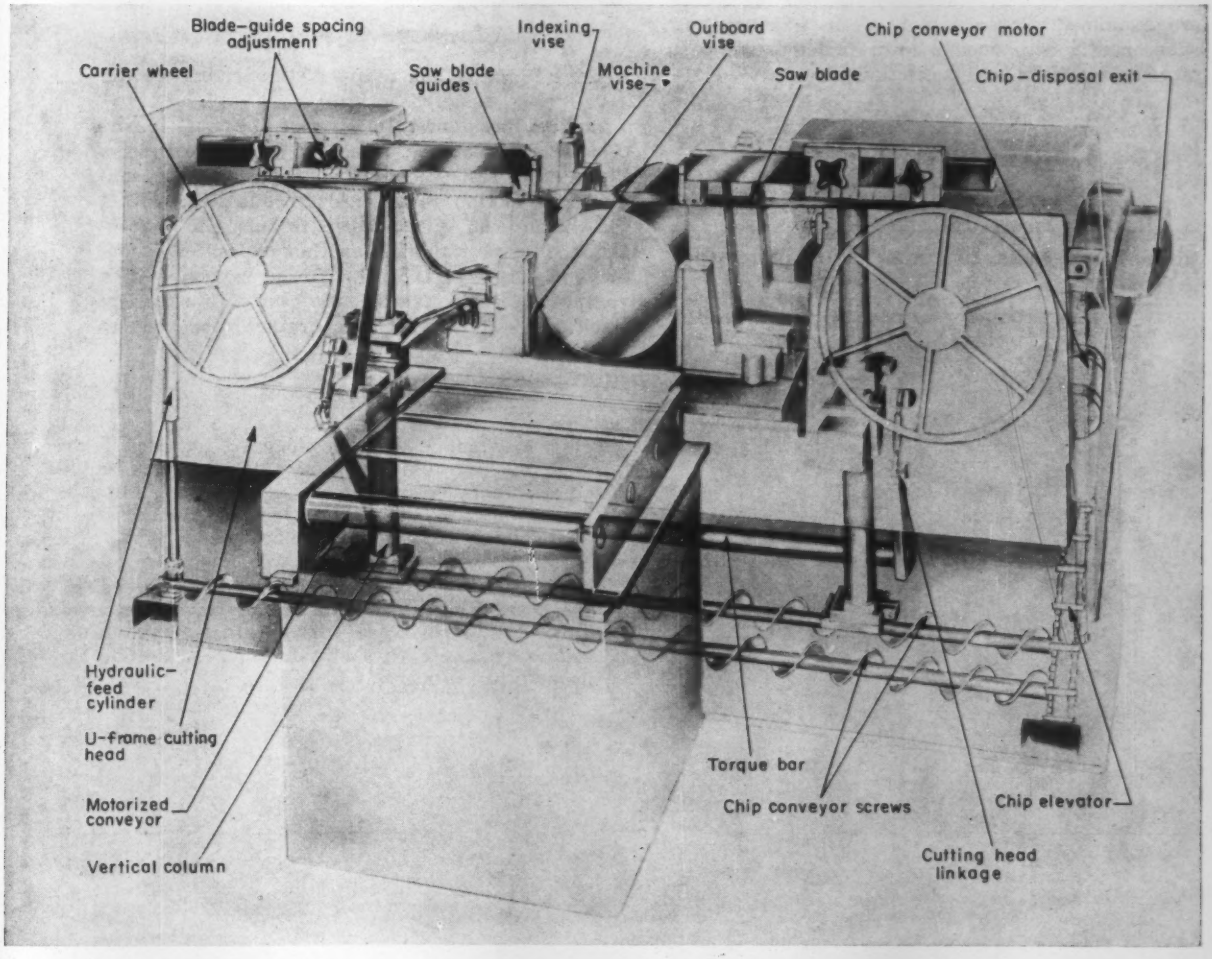
Hydraulic clamping vises mounted on the work table hold stock in position during sawing. The main machine vise is located before the blade and the smaller outboard vise after the blade. An automatic indexing vise, which is hydraulically operated, is available as accessory equipment.

Feed and Indexing Control System

U-shaped frame used in the design of the cutting head is made of heavy steel weldments. On each end of the cutting-head frame are mounted the saw-band wheels, inclined at 21½ degrees from the vertical and mounted on antifriction bearings. The saw-blade guides, the hydraulic band-tensioning mechanism, band wheels, and the hydraulic motor powering the driven band wheel are all carried by the cutting-head frame.

The cutting head travels vertically on two columns, rising from the machine base at either end, which are fastened to the heavy table casting of the machine at the mid-section and the table frame on the bottom. Between each extreme end of the U-frame and the machine base is mounted a hydraulic cylinder. These two cylinders furnish the power to raise the cutting head and provide a means of carefully controlling its downward movement.

To assure equal movement on each end of the cutting head, a torque bar is mounted in the machine base. The ends of the torque bars are connected by arms and linkage to the ends of the cutting head, so that any movement of either end of the cutting head is immediately transmitted to the other end.



Mechanics of Vehicles—5

By Jaroslav J. Taborek*
Development Engineer
Towmotor Corp.
Cleveland

POWER is expended when a vehicle moves against a resisting force. In accelerated motion uphill, the forces or resistances that oppose the motion of a vehicle are: (1) Rolling resistance, (2) Grade resistance, (3) Air resistance, (4) Inertia resistance, and (5) Transmission resistance.

Here and in a following article, the magnitudes and characteristics of these motion-resisting forces are examined. Consideration of such forces will subsequently be shown to form an important part of vehicle performance prediction.

Force Characteristics

To move a vehicle at speed V (mph) against any resisting force R_x (lb), power N_x must be delivered to the driving axle. Magnitude of the power (hp) is given by

$$N_x = \frac{R_x V}{375} \tag{50}$$

At any instant, the sum of all resisting forces ΣR_x is in equilibrium with the tractive force P, which is delivered as torque M_d to the driving wheels. Such a force balance is expressed as

$$\frac{M_d}{r} = P = \sum R_x \tag{51}$$

where r is the rolling radius of the driving wheels.

Rolling Resistance: In a sense, the most important of the resisting forces is rolling resistance. While other resistances act only under certain conditions of motion, rolling resistance is present from the instant the wheels begin to turn. Rolling resistance, in addition, has another undesirable property: a large part of the power expended in a rolling wheel is converted into heat within the tire itself. The consequent temperature rise reduces

*Now Research and Development Engineer, Phillips Petroleum Co., Bartlesville, Okla.

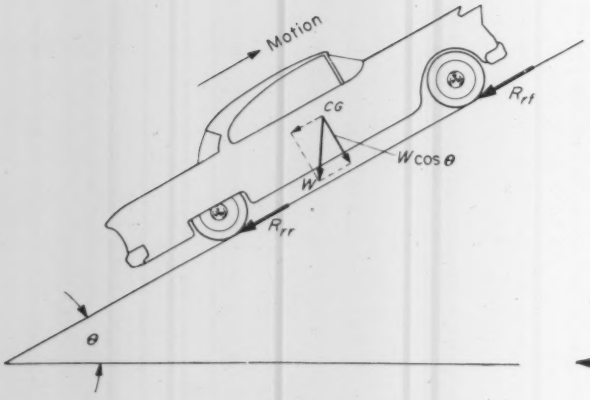
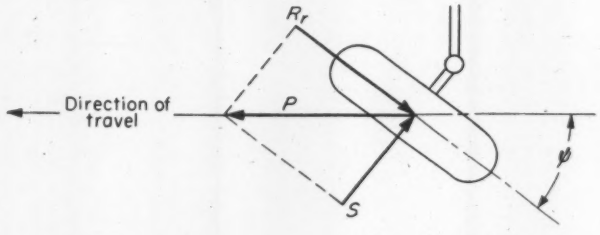


Fig. 35—Left—Rolling resistance of a vehicle is the sum of the rolling resistances of all wheels and is therefore independent of weight distribution. The weight used in rolling-resistance calculations is the normal (cosine) component of vehicle weight.

Fig. 36—Below—The rolling plane of the wheel is not parallel with the direction of travel. Tractive force P must overcome the vectorial resultant of rolling resistance R_r and side force S. Rolling is maintained as long as $f \tan \psi < \mu$.



Motion-Resisting Forces

- **rolling resistance**
- **grade resistance**

both the abrasive resistance and the flex fatigue of the tire material and becomes the limiting factor on tire performance.

Differing basically from resistance sources for rigid wheels (Part 1 of this series), the sources of rolling resistance on pneumatic tires are:

(1) Work performed by flexing of the tire body as it passes the ground contact area.
(2) Work performed by the wheel penetrating or compressing the ground.
(3) Work performed by frictional motion due to tire slip.
(4) Friction caused by air circulation inside the tire and the fan effect of the rotating wheel on the outside air.

The first two of these factors account for the greater part of rolling resistance; the remaining two have only secondary effect. Considering the vehicle as a whole, the total rolling resistance R_r is the sum of the resistances of all the wheels, or

$$R_r = R_{rr} + R_{rf} = fW \cos \theta \qquad (52)$$

where R_{rf} and R_{rr} designate rolling resistances on front and rear wheels, $W \cos \theta$ is the normal-to-ground component of vehicle weight, and f is the coefficient of rolling resistance, Fig. 35.

For theoretically correct calculations, the dy-

Nomenclature

f = Coefficient of rolling friction
G = Measure of grade, per cent
N = Power, hp
P = Tractive force on driving wheels, lb
R_g = Grade resistance, lb
R_r = Rolling resistance, lb
r = Rolling radius of tire, ft
S = Side force on tires, lb
V = Speed, mph
W = Vehicle weight, lb
θ = Horizontal incline of road, deg
μ = Friction coefficient
ψ = Slip angle, deg

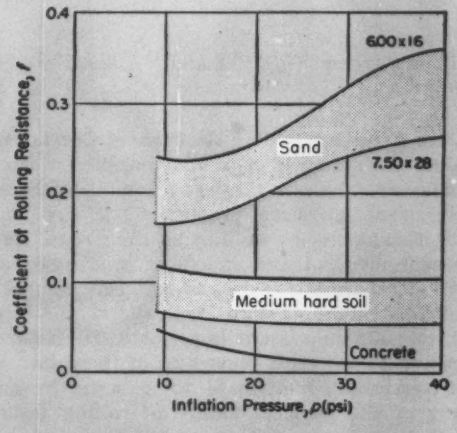


Fig. 37—Coefficient of rolling resistance as a function of inflation pressure. Values plotted assume reasonable vehicle speeds for each surface type.

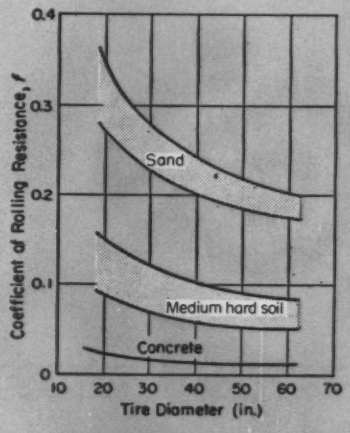


Fig. 38—Coefficient of rolling resistance as a function of tire diameter. Effect of tire diameter is negligible for hard surfaces (concrete) but decisive for soft ground or sand.

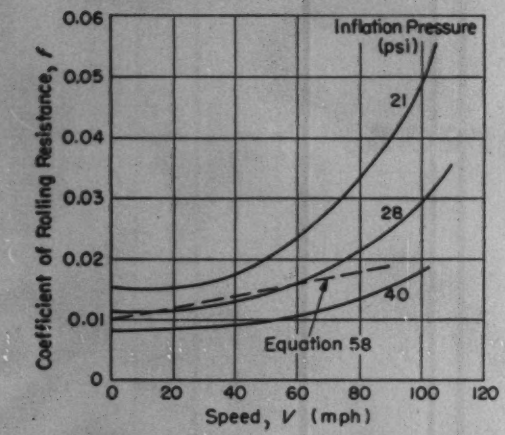


Fig. 39—Coefficient of rolling resistance as a function of speed. The effect of speed is more pronounced at lower inflation pressures. Curves for pressures of 21, 28 and 40 psi were calculated from Equation 57. An approximation for common passenger car speeds and inflation pressures is given by the plot of Equation 58.

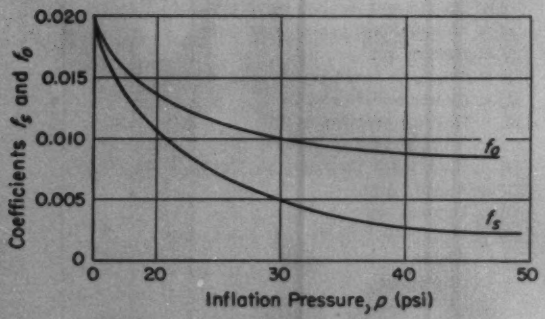


Fig. 40—Supplementary coefficients f_0 and f_s for use in Equation 57.

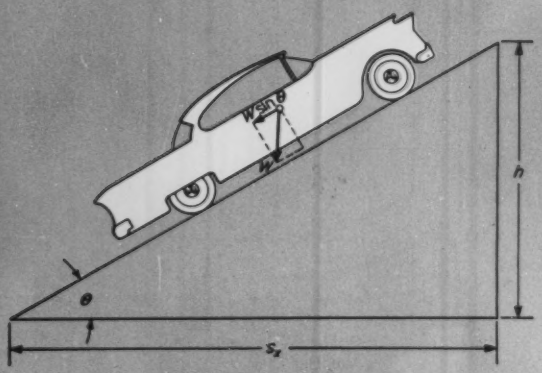


Fig. 41—Grade resistance of a vehicle is the downhill component of its weight. Grade is usually measured in per cent where G (%) = (100 b)/s_x = 100 tan θ.

namic weight of the vehicle, including the effects of acceleration, trailer pull and the vertical component of air resistance, is used. For vehicle performance estimation, however, the changing magnitude of the dynamic weight complicates the calculations without offering significant improvements in accuracy. Furthermore, it is apparent from Equation 52 that a dynamic weight transfer toward one of the axles has no influence on the total rolling resistance.

For these reasons, static vehicle weight is usually taken as sufficiently accurate for computation of rolling resistance. As a further simplification, the effect of the horizontal grade angle θ is often neglected completely. Equation 52 then becomes

$$R_r = fW \cos \theta \approx fW \qquad (53)$$

The error introduced by this simplification is only 5 per cent for the steepest existing grades (about 32 per cent).

All these considerations apply, in a strict sense, only for straight-line motion. For vehicles on curves, the direction of rolling deviates from the direction of actual travel, and the tractive force P must overcome the vectorial resultant of side force S and rolling resistance R_r, Fig. 36. In this case,

$$P = \frac{R_r}{\cos \psi} \qquad (54)$$

where ψ is the slip angle, that is, the angle between the speed vector and the rolling plane of the wheel.

On a steered wheel, the side force S necessary to maintain equilibrium of forces must remain within the limits of sliding friction given by the radial load W and the friction coefficient μ, or

$$S = R_r \tan \psi \leq \mu W \qquad (55)$$

These results, when combined with Equation 53, give the condition for rolling of the steered wheel as

$$f \tan \psi \leq \mu \qquad (56)$$

For slippery ground ($\mu = 0.2$ and $f = 0.02$), Equation 56 gives $\psi_{max} = 84$ deg.

Factors Affecting Rolling Resistance: Coefficient of rolling resistance f is a dimensionless factor that expresses the effects of the complicated and interdependent physical properties of tire and ground. Establishment of standardized conditions for measurement of the effects of variables like the fine structure of the ground material, composition of the rubber, design elements of the tire, etc., proves difficult if not impossible. The following account of the most important of these factors will, nevertheless, contribute to a better understanding of the physical nature of rolling resistance.

GROUND-SURFACE STRUCTURE: Lowest f values are measured on hard, smooth, dry surfaces. A worn-out road almost doubles rolling resistance. On wet

surfaces, higher rolling resistances are observed, probably due to the cooling effect of the water and the correspondingly decreased flexibility of the rubber tire.

TIRE-GROUND ELASTICITY: The relative elasticity and hysteresis of both tire and ground are important factors that decisively influence rolling resistance. Three basic combinations are possible: (1) The tire is rigid as compared to soft, plastic ground, rolling resistance being due to penetration work only; (2) Both tire and ground are deformable, rolling resistance being due to both tire deformation and ground penetration work; and (3) The ground is rigid in relation to an elastic tire, rolling resistance being due entirely to tire deformation work.

TIRE INFLATION PRESSURE: To a large extent tire inflation pressure determines elasticity of the tire. It affects the value of f in a manner that depends on the elasticity of the ground, Fig. 37. For example, the following situations can be distinguished:

On plastic surfaces, like sand, high inflation pressures result in increased ground penetration work and therefore higher f values. Conversely, lower inflation pressures, while decreasing ground penetration, increase tire-flexure work. Obviously, an optimum pressure exists for a given surface.

On medium plastic surfaces, like grass sod, the effects of inflation pressure on tire and ground approximately balance, and f remains nearly independent of inflation pressure.

On hard surfaces, f decreases with higher inflation pressure, since flexing work of the tire body will be greatly reduced.

TIRE RADIUS: Basically, f is inversely proportional to rolling radius. The proportionality factor, however, is small on hard surfaces, becoming important on soft, plastic ground, Fig. 38.

DRIVING SPEED: Coefficient f is directly proportional to speed because of increased flexing work and vibration in the tire body. Consequently, the influence of speed becomes more pronounced when speed is combined with lower inflation pressures, Fig. 39.

TRACTIVE FORCES: Wheels transferring tractive or braking forces show higher rolling resistance due to wheel slip and resulting frictional scrubbing.

RADIAL LOAD: Coefficient f is directly proportional to radial load due to the effect of load on tire deflection. This influence is, however, revealed only by exact measurement.

TEMPERATURE: Coefficient f decreases with increasing temperatures (ambient or internal) as a result of increased flexibility of the rubber.

TIRE MATERIAL AND DESIGN: Thickness of the tire base, usually expressed in plies, and thickness of the rubber tread determine the amount and stiffness of material to be deformed by rolling. Worn-out, smooth-tread tires show f values up to 20 per cent lower than new ones. Often for racing cars, the rubber tread is ground off to small fractions of an inch. Fine laminations, on the other hand, increase f as much as 25 per cent. The cord material in the tire carcass has only negligible effect; the rubber material and its compounding is of much greater importance. Synthetic rubber generally shows higher f values than natural rubber.

Determination of Rolling-Resistance Coefficient: The multiple and interrelated factors affecting f make it virtually impossible to devise a formula that takes all variables into account. Before a value of f is chosen for a particular application, the overall degree of accuracy required for the calculations should be established.

On test runs where other measurements are being performed, it may be essential that f be known as exactly as possible. Several equations for f have been developed for passenger-car tires rolling on

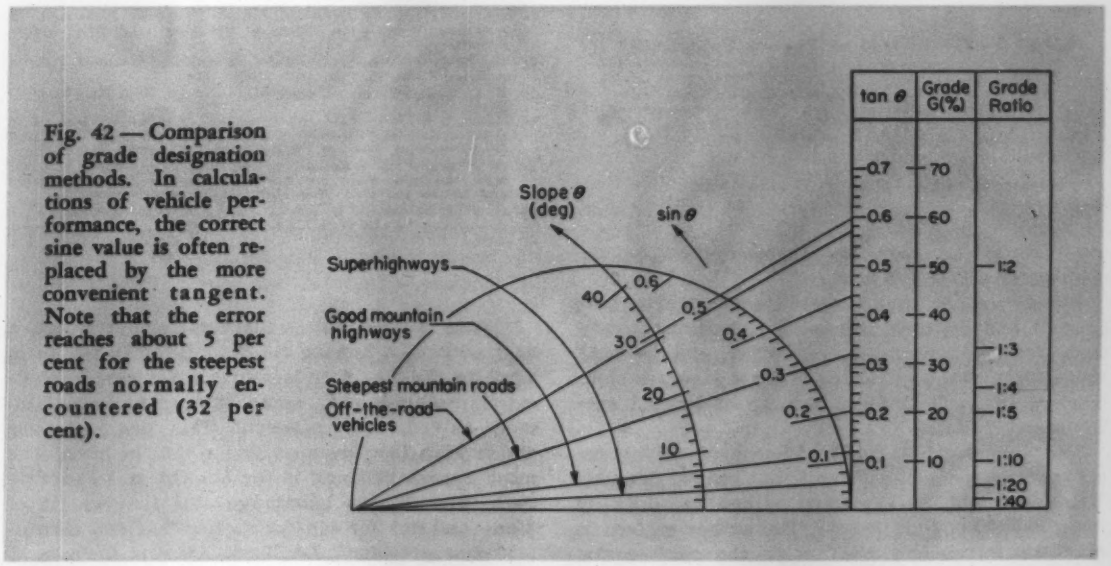


Fig. 42 — Comparison of grade designation methods. In calculations of vehicle performance, the correct sine value is often replaced by the more convenient tangent. Note that the error reaches about 5 per cent for the steepest roads normally encountered (32 per cent).

concrete surfaces. The variables in these equations are usually inflation pressure, speed and radial load. The accuracy of such a calculation is naturally limited by the influence of factors that are neglected. Laboratory measurements usually give f with steel as a ground surface. For concrete, a new value can be recalculated by use of established conversion factors.

For soft and plastic grounds it is very difficult to find accurate data of general validity. The structure of these materials is hardly definable and will change from place to place. Average values are usually accepted and seldom should there be need for any higher accuracy.

Relatively accurate values of f for concrete surfaces as function of inflation pressure and speed can be calculated from the following equation developed at the Institute of Technology in Stuttgart:

$$f = f_o + 3.24\, f_s \left(\frac{V}{100} \right)^{2.5} \qquad (57)$$

Here, V is speed (mph), the factor f_o represents the basic coefficient and f_s determines the speed effect. Both factors are taken from the diagram in Fig. 40. Equation 57 is also plotted with inflation pressure as a parameter in Fig. 40.

For many performance calculations, it is often sufficiently accurate to express f as a linear function of speed. For the most common range of inflation pressures (around 26 psi), the following equation gives average values of f for concrete surfaces:

$$f = 0.01 \left(1 + \frac{V}{100} \right) \qquad (58)$$

The range of acceptable accuracy of this equation is up to about 80 mph. The advantage of this expression is that it can be substituted directly into other equations, therefore expressing rolling resistance as a function of speed.

Table 3—Coefficient of Rolling Resistance*

Vehicle Type	Surface			
	Concrete	Medium Hard		Sand
Passenger cars	0.015	0.08	0.30	
Heavy trucks	0.012	0.06	0.25	
Tractors	0.02	0.04	0.20	

*Dimensions of f are lb per lb of vehicle weight.

In many cases, even the effects of speed can be ignored and average values of f, covering conditions for the particular application, can be used in performance calculations. Such values are summarized in Table 3 for a variety of ground surfaces and vehicles.

The dimension of the coefficient of rolling resistance is pound per unit of vehicle weight. Vehicle weight is expressed either in units of pounds, 1000 pounds or tons. The author prefers to keep all forces and weights in the same units, avoiding unnecessary complication by the the introduction of new units.

Grade Resistance: Grade resistance R_g is the component of vehicle weight acting downhill, Fig. 41. It is given by

$$R_g = W \sin \theta \qquad (59)$$

In practice, it is customary to designate grade G (per cent) as the ratio of the climbed height to the projected horizontal distance, or

$$G = \frac{h(100)}{s_x} = 100 \tan \theta \qquad (60)$$

Allowing for the approximation that for small angles $\sin \theta \approx \tan \theta$, the grade resistance equation becomes

$$R_g \approx W \tan \theta = \frac{WG}{100} \qquad (61)$$

The error resulting from this simplification for the steepest known road grades (32 per cent or 18 deg) reaches an acceptable 5 per cent. For more exact calculations, or for still steeper grades, the simplification should not be used.

A comparison of grade designation methods is given in Fig. 42. Grades of modern super highways are kept below 6 per cent (3½ deg); in mountain areas, dual-highway up-hill slopes reach 7 per cent and downhill slopes are up to 8 per cent. Average mountain highways are kept under about 12 per cent (7 deg); the steepest known roads in high mountains reach slopes up to 32 per cent (18 deg) for short distances. Off-the-road and military vehicles are usually designed to negotiate slopes of 60 per cent (31 deg).

The highest grade that a vehicle can climb is called its gradability and is designated as G_{max} (per cent) or θ_{max} (deg).

BIBLIOGRAPHY

30. Billingsley, Evans, Hulswit, Roberts—"Rolling Resistance of Pneumatic Tires as a Factor in Car Economy," *SAE Transactions*, 1942.
31. McKibben—"Transportwheels for Agricultural Machines," *Agricultural Engineer*, Nov. 1939—Aug. 1940.
32. T. R. Agg—*Bulletin* 88, Iowa State College, Eng. Exp. Station, 1928.
33. Kamm, Schmidt—Das Versuchs-und Messwesen auf dem Gebiete des Kraftfahrwesens (Experimentation and Measuring on Automotive Vehicles), Springer Verlag, Berlin, 1939.
34. C. Schmidt—Die Fahrwiderstaende beim Kraftfahzeug und die Mittel zu ihrer Verringerung (Vehicle Motion Resisting Forces and Means for Their Reduction), AZT, Stuttgart, 1938.
35. L. C. Lundstrom—"Wind and Rolling Resistances," Part 4 of Symposium "Where Does All the Power Go?" *SAE Transactions*, 1957.

"These million dollar machines aren't worth a cent without a human, thinking being to tell them what to do. The fact is that all our new, complicated machines only make Man more important, more skilled, more powerful. They are just tools which Man has invented and which he uses. The most important thing is for Man to make sure he uses them to his advantage—for the benefit of Man—and not for his destruction."—CARL KOTCHIAN, *vice president, Lockheed Aircraft Corp.*

The Personal Side of Engineering

By Edwin C. Nevis
Personnel Research and Development Corp., Cleveland

The Engineer as an Executive

IN the last fifty years the number of engineers holding high executive positions has increased greatly. One study of executives reports that in 1900 only 12.5 percent of the top executives of major corporations (including railroad and utilities) were engineers by training and primary occupation. In 1950 this number had increased to 19.3 per cent of top corporation executives.

The pattern is similar in smaller businesses where more and more engineers act as both a technical head and an administrative officer. This trend is not surprising. The demands of modern technology have accelerated development of potential leaders with engineering backgrounds.

Yet, despite the obvious need and place for engineers in executive capacities, engineers are often said to make poor executives. One hears that they do not know how to get along well with subordinates; that they fail to use diplomacy; that they are weak in long-term planning; that they insist upon doing things in their own ways, rather than in accordance with company policy. Another comment is that engineers are too valuable in positions calling for technical precision and careful attention to detail to be assigned to executive capacities involving broad planning and extensive work with people.

Both of these attitudes represent extremes, for the fact is that engineers can and do make good executives. In several studies, intensive appraisal has indicated at least one-third of a company's engineering group to be capable of development to managerial and executive levels. And in some companies the number may be even greater.

However, engineers as executives do face one basic problem which is probably most responsible for criticism of their performance. This is the fact that, as a group, engineers experience difficulty in obtaining results through others, as opposed to obtaining results as a consequence of their own direct efforts. In short, engineers in executive capacities have problems in delegating and in then applying a sympathetic attitude toward the frailties of the humans they supervise. This is particularly true during the initial stages of assignment to an executive capacity. Often the transition must be made abruptly from the role of independent specialist to that of group leader.

The reason why this proves to be difficult is found, paradoxically, in a quality of the engineer which represents one of his major assets: his dedication to the individual attainment of tangible, factually sound accomplishments. Most of an engineer's formal training and all of his experience up to the point of appointment to a managerial position are geared to development of an alert-minded, critical and logical attitude. An engineer is supposed to understand and solve technical problems on their scientific merits only. Being right in a factual sense becomes an all-important professional goal. Too, the major work satisfaction of most engineers lies in the fact that they can see tangible results follow from the "sweat of their brows."

The main function of an executive, however, is to see that results are obtained through the work of others. The role is that of the overseer, the compromiser, the director, the inspirer of the efforts of others. It is no wonder that engineer-executives are frequently bewildered when first faced with the task of understanding subordinates who have been given assignments and, for one reason or another, do not achieve results.

What many men in such positions fail to understand is that their own personal deficiencies may be at work. For example, many engineers, because of their early training and experience, never really acquire good communication skills. When working more or less alone they may not have to communicate often with others. However, the cause of most supervisory difficulties is a failure in communications. When a subordinate fails in a task, where else should a supervisor begin in seeking the reason but to ask himself if the task was understood by the subordinate? On

this point alone many engineer-executives fall down. They fail to recognize that their own inconsistencies as humans may be a factor.

The engineer who goes into executive work in research may be able to use some theoretical absolutes as guides in decision making. However, most development, application, production, administration, and sales problems arise out of a need for compromise between various alternatives, all of which have some degree of "truth."

In such situations the going is more difficult. Such is the case certainly in all problems involving human relations. The engineer who would become a smoothly functioning executive has to think and act in terms of compromises. He must recognize that there is more than one "truth," particularly in regard to the attitudes of people toward their job, their company, and their coworkers. If he achieves this goal, his task of obtaining results through others can be greatly eased. This does not mean that the engineer-executive should become a "softy." But it does mean that he can use his firmness and result-mindedness more effectively — if his attitude toward his job is flexible rather than persistently single-minded.

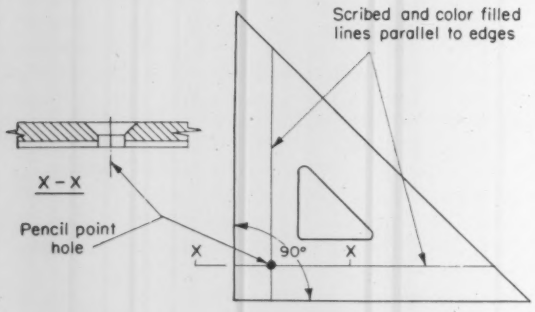
Tips and Techniques

Simplified Slide Rule Technique

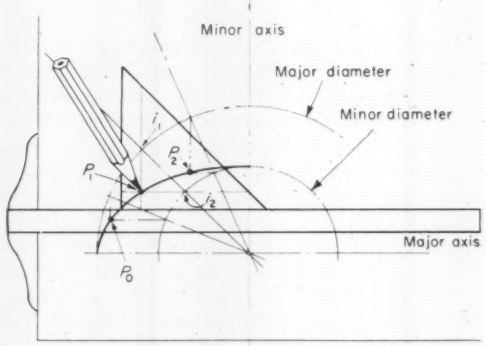
Finding square roots of the sum or difference of two squares on the slide rule may be simplified by using the following technique. As as example, consider finding $Z = \sqrt{4^2 + 3^2}$, which is 5. First divide the larger of the two numbers by the smaller and read the square of the result, in this case 1.777, on the *A* scale. Next add 1 to this result by moving the indicator along the *A* scale to that sum. This is 2.777 for the example. Now multiply the square root of this number, indicated on the *D* scale, by the smaller number, 3. To adapt the method to finding the difference of the squares of two numbers, such as $X = \sqrt{5^2 - 4^2}$, it is only necessary to subtract 1 rather than adding it after finding the square of the larger number divided by the smaller.—JAMES M. AITKEN, *Massachusetts Institute of Technology, Cambridge, Mass.*

Plotting Ellipses

A triangle modified as shown may be used to quickly plot points defining the boundary of an ellipse. To use the gadget, two circles having



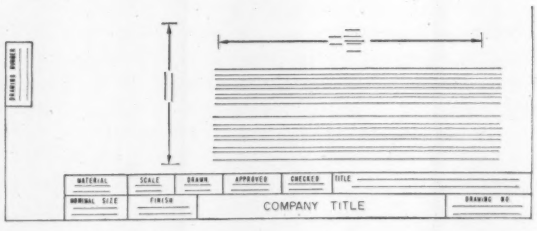
diameters equal to the major and minor axes of the ellipse are lightly constructed. A number of radii intersecting both circumferences are then constructed. When the triangle is positioned on the



straightedge so that radii, circumferences and the lines on the triangle intersect, the intersection of the lines on the triangle is a point on the ellipse. As many points as are required may be quickly plotted in this manner and then joined by a smooth curve.—ALFRED TEPLITZ, *Pittsburgh, Pa.*

Lettering Guide

A master guide template incorporating guide lines with various spacings, a title block with appropriate guide lines and guide lines for dimensioning can be very useful. The template is prepared by inking the desired lines on a piece of bristol board. To use the template, simply place it underneath the drawing or tracing. This method conserves the time necessary to draw the guide lines and results in a cleaner drawing.—ROBERT BENNETT, *Bird Electronics Corp., Cleveland, O.*



Nomogram speeds design of

Helical Compression Springs

to meet specific size and load requirements

By John H. Keyes
Douglas Aircraft Co.
Tulsa, Okla.

DESIGN of helical compression springs for specific size and load requirements normally requires a number of trial and error computations. As a shortcut to this procedure, the nomogram presented here has been developed for rapid preliminary solution of spring design problems.

Springs must often be designed to operate freely over a rod of given size or in a hole of specified diameter. In addition, they may be required to provide a specific length under certain load conditions. Design of helical compression springs to meet these and other similar requirements is greatly simplified by the accompanying nomogram. Use of the nomogram, which was developed for steel springs with shear modulus G = 11,000,000 psi, is based on a nine-point procedure outlined overleaf in *Method of Solution*.

Example Problem: Design a helical compression spring which will move freely in a hole of 1 3/16 in. diameter and will carry 32 lb at a length of 4 in. and 56 lb at a length of 3¼ in.

Nomenclature

C = Stress correction factor (Wahl)
D = Mean coil diameter (outside diameter of coil minus wire diameter), in.
d = Wire diameter, in.
F = Total spring travel or deflection, in.
f = Deflection per coil per pound of load, in.
G = Shear modulus, psi
H = Free height, in.
h = Solid height, in.
H_1, H_2 = Spring height under loads P_1 and P_2, respectively, in.
$K = P/F$ = Spring rate or gradient, lb per in.
N = Number of active coils
P = Spring load, lb
$p = F/N$ = Pitch height of coil minus wire diameter, in.
s = Wire stress (shear), psi
X = Intercept on reference line

On the P and F scales, locate $P = P_2 - P_1 = 56 - 32 = 24$ lb and $F = H_1 - H_2 = 4.000 - 3.250 = 0.750$-in. Intersection of a line through these points with the K scale gives spring rate or gradient K = 32 lb per in. Through this point, from P_1 = 32 lb on the P scale, draw a line to intersect the F scale. At the intersection, find F_1 = 1.000 in., which is the travel or deflection for initial load P_1. Free length, therefore, is $H = 4.000 + 1.000 = 5.000$ in.

Select trial values of coil diameter D and wire diameter d. Sum of these values must be less than the diameter of the hole in which the spring is to operate. For this example, D = 1 in. and d = ⅛-in. will be arbitrarily selected. Connect these points with a line, finding spring index D/d = 8 and specific deflection f = 0.00298-in. This line also intersects reference scale X at a point which will be used for reference later in the solution.

From K = 32 lb per in., draw a line through f = 0.00298-in., intersecting the N scale at N = 10.49 active coils. If the spring is to have two inactive coils, in accordance with standard practice, connect N = 12.49 (total number of coils) with d = 0.125-in., finding solid height h = 1.562 in. Total deflection or travel then is $F = 5.000 - 1.562 = 3.437$ in. From this point on the F scale, draw a line through K = 32 lb per in., meeting the P scale at maximum load P_{max} = 110 lb.

Pitch p of coils can be found by either of two index lines: (1) from P_{max} = 110 lb through f = 0.00298-in. or (2) from F = 3.437 in. to N = 10.49. Both lines should intersect the p scale at pitch p = 0.3285-in. Adding the wire diameter, d = 0.125-in., to this value gives the pitch per coil at free height, 0.453-in.

These data represent the basic design details of the spring. The remaining two steps serve merely as a check on the validity of the design from a

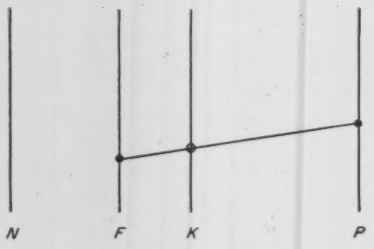
practical standpoint. From $C = 1.18$, which is the value of the Wahl correction factor corresponding to spring index $D/d = 8$, draw a line through the reference point located previously on reference scale X. Extending this line to the s/P scale gives $s/P = 1550$ psi per lb of load. Through this point, draw a line from $P_{max} = 110$ lb, intersecting s scale at maximum stress $s_{max} = 171{,}000$ psi.

If this stress value is considered satisfactory from the standpoints of available spring materials and anticipated operating conditions, the trial run may be used as the basis for more accurate computations. If a lower maximum stress is desired, or a higher one permissible, the procedure can be quickly repeated until a more suitable solution is reached, using other combinations of coil and wire diameters.

Method of Solution

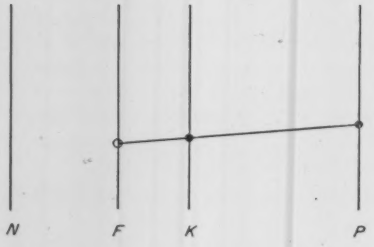
1. Spring rate, K

$$K = \frac{P_2 - P_1}{H_1 - H_2}$$



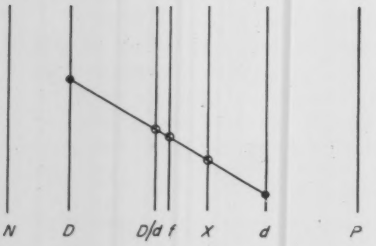
2. Initial deflection, $H - H_1$

$$H - H_1 = \frac{P_1}{K}$$



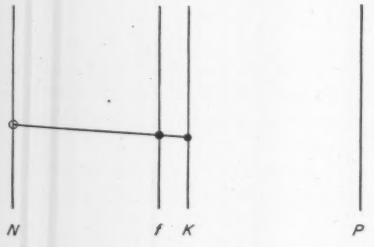
3. Specific deflection, f

$$f = \frac{8D^3}{Gd^4}$$



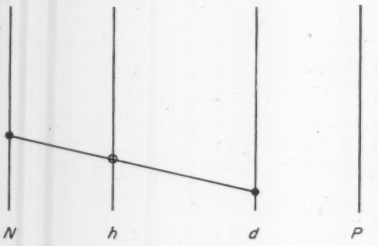
4. Number of active coils, N

$$\frac{1}{N} = fK$$



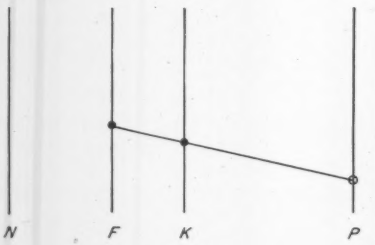
5. Solid height, h

$$h = d(N + 2)$$



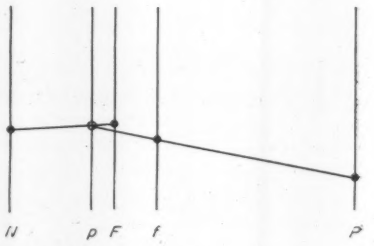
6. Maximum load, P_{max}

$$P_{max} = KF$$



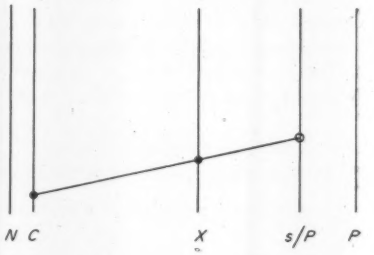
7. Coil pitch, p

$$p = fP_{max} \qquad p = \frac{F}{N}$$



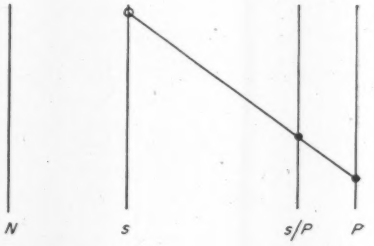
8. Specific wire stress, s/P

$$\frac{s}{P} = XC \qquad X = \frac{8D}{\pi d^3}$$



9. Maximum stress, s_{max}

$$s_{max} = \frac{s}{P} P_{max}$$



Spring Design Nomogram
Load P
Unit wire stress s/P
Wire number
Wire diameter d
Reference X
Spring rate K
Specific coil deflection f
Spring index D/d
Stress s/1000
Total spring travel F
Solid height h
Coil pitch p
Coil diameter D
Correction factor C
D/d
Number of active coils N

Recent Developments in

High-Temperature Alloys

By N. E. Promisel
Navy Department
Bureau of Aeronautics
Washington 25, D. C.

RECENT developments of alloys for high-temperature structural applications have been made primarily in the 400 to 1500 F range and higher.

Between 400 and 1500 F

A careful review of each new alloy application is necessary to produce a composite material in which each element contributes certain characteristics.

Magnesium alloys with 2 to 3 per cent additions of thorium to previous contents of zinc, zirconium and manganese, show improved elevated temperature properties. For cast and rolled forms, alloy HK31 contains nominally 3 per cent thorium and 0.7 per cent zirconium. For casting, HZ32 is approximately the same alloy but with an added 2 per cent zinc. Another new casting alloy, ZH62A, contains 6 per cent zinc, 1.6 per cent thorium and 0.7 per cent zirconium. For sheet and extrusions, alloy HM31 contains 3 per cent thorium and 1 per cent manganese. At 400 F, the HK31 alloy increases in strength with time.

Heat-treated aluminum alloys which are best for high strength at room temperature lose their advantage as they approach 400 F. Alloy 2024 in the T86 temper shows superior characteristics. Better characteristics are also shown by a forging alloy with about 2 per cent copper, 1 per cent iron, 1.6 per cent magnesium, 1 per cent nickel and 0.07 per cent titanium; and by an alloy for all wrought forms, of 6 per cent copper, 0.3 per cent manganese, 0.1 per cent vanadium and 0.15 per cent zirconium. For castings, a fairly new alloy, XA140, of 8 per cent copper, 6 per cent magnesium and 0.5 per cent each of manganese and nickel, is markedly superior to other aluminum casting alloys at 600 F.

Titanium alloys have strengths equal to those of fairly high-strength steels but weigh approximately 40 per cent less and have generally high corrosion resistance. Progress has been made toward development of titanium alloys for application at 1000 F with room-temperature tensile strengths of approximately 200,000 psi. There are a number of encouraging possibilities for significant reduction in cost of titanium.

Iron-aluminum alloys have had a lack of ductility which discouraged serious consideration of compositions containing more than 6 to 8 per cent aluminum. Recent vacuum melting and planetary rolling-mill techniques are producing thin sheets of iron-aluminum alloys with a content of 16 per cent aluminum for use as magnetic material. Addition of 3 per cent molybdenum results in a product called Thermenol, Table 1. Thermenol has excited considerable interest because of the absence of critical materials from its compo-

Table 1—Comparative Properties of Thermenol and Other Alloys

	Thermenol	Stainless 302-1/2 H	Titanium Comm. Pure	Aluminum 2024-T4	Magnesium AZ31
Modulus of elasticity....	24×10^6	29×10^6	16×10^6	10.3×10^6	6.5×10^6
Density (gm/cm³)	6.58	7.93	4.5	2.77	1.78
Resistivity (microhm-cm)	160	72	54	5.7	9.3
Relative corrosion resistance, sea water..	Good	Excellent	Excellent	Good	Poor
Relative oxidation resistance at 1600 F....	Excellent	Good	Unusable	Unusable	Unusable
Relative weldability	Good	Excellent	Fair-good	Fair-good	Good
Relative machinability ..	Fair	Fair	Fair	Excellent	Excellent
Relative workability	Poor	Good	Good	Good	Fair
Maximum permeability ..	130,000	Nonmagnetic	Nonmagnetic	Nonmagnetic	Nonmagnetic
Cost of sheet per lb (dollars)	3.00	0.50	20.00	0.50	0.75

Table 2—Refractory Metals

	Melting Point (F)	Density (gram/cu cm)	Modulus of Elasticity (psi x 10^6)
Tungsten	6170	19.3	50
Rhenium	5740	20.0	42
Tantalum	5425	16.6	27
Osmium	4900	22.5	80
Molybdenum	4760	10.2	45
Iridium	4450	22.5	75
Niobium	4380	8.57	19
Chromium	3430	7.19	36
Zirconium	3380	6.5	14
Titanium	3140	4.5	16
Vanadium	3125	6.11	21-22.5
Hafnium	3100	11.4	20

sition, its low density, good strength to 1000 F and higher, and its impressive resistance to oxidation. Vacuum arc melting with added grain refiners, followed by controlled heat treatment, causes a simultaneous doubling of strength and ductility.

Steel developments in the last few years fall into two major categories:

1. Increasing strength in large sections to values of approximately 300,000 psi tensile strength at room temperature.
2. Improving strength and other properties for use up to about 1000 F, primarily for sheet and other flat-rolled products.

Higher strength in larger sizes has been achieved with low tempering temperatures of carefully controlled chrome-nickel-molybdenum steel, or by juggling these elements with silicon and minor additions of vanadium, boron, aluminum and titanium. One such steel, developed at the National Bureau of Standards, contains nominally 0.4 per cent carbon, 0.75 per cent manganese, 1.60 per cent silicon, 0.85 per cent chromium, 0.30 per cent molybdenum, 1.80 per cent nickel, 0.10 per cent titanium and 0.002 per cent boron.

The second development emphasizes problems of lower-temperature materials. Interesting compositions include two chrome-nickel stainless steels, 17-7PH and AM-350, containing about 1 per cent aluminum and 3 per cent molybdenum, respectively. Both depend on transformation from austenite to martensite, followed by precipitation and tempering, respectively, with resulting tensile strength up to about 225,000 psi. Both have good elevated-temperature properties, corrosion resistance and formability.

Above 1500 F

Studies of chrome base alloys indicate feasibility of 40 to 45 per cent chromium, 45 to 50 per cent nickel, 2 to 10 per cent iron, 2 per cent molybdenum and 2 per cent niobium. The 1800 F rupture life for alloys of this type is superior to that of current nickel base alloys hardened with aluminum and titanium. Vacuum melting and other advanced techniques obtain further improvements both in the 45 per cent chromium area and in alloys containing 60 to 90 per cent chromium.

Refractory metals are listed in Table 2. The only real deterrent to more extensive use of molybdenum is the absence of a reliable coating to prevent oxidation at high temperatures. Applications of outstanding importance are those where temperatures of 1800 to 2000 F are sought, but where suitable materials are lacking because of the presence of high static and vibratory stresses. Molybdenum is the most promising material at this time. These requirements dictate that the coating and its method of application must not deteriorate the molybdenum alloy and must not develop unhealed surface defects under creep conditions or when elongated a few per cent in a hot-tensile test.

Protective coatings are listed in Table 3. Cladding has been successful with the obvious limitation that it cannot be applied to a finished object. Another promising coating is chromium electrodeposited to a thickness of 1 mil, followed by nickel 5 to 10 mils thick.

Graphite sublimates at about 7000 F which is as high as, or above, the melting or sublimation temperature of any other refractory material. It does not melt, except under simultaneous conditions of temperatures exceeding its sublimation temperature, and pressure in excess of 3500 atmospheres. Other valuable properties are its very low density, high thermal conductivity, machinabilit, and high availability. Resistance to corrosion under oxidizing conditions can be improved in one of several ways:

1. Alloying with other refractory materials.
2. Use of protective surface layers.
3. Impregnation with materials which reduce porosity and improve immunity to attack.

Graphite impregnated with refractory metal resists oxidizing atmospheres at temperatures well over 4000 F without dimensional change.

Cermet binders for applications above 1500 F must be designed to have high melting points, high temperature strengths, ductility at low and high temperatures, thermal shock resistance, oxidation or environment resistance and ability to "wet" the refractory or ceramic portion of the cermet. Metal binders have been limited primarily to nickel and cobalt alloys with current grades running 50 to 70 per cent binder content for improved ductility, impact resistance and thermal shock resistance of the cermet.

For the ceramic or refractory portion of the cermet, possibilities lie in carbides, borides, oxides, silicides, nitrides, etc., which are extremely hard, brittle and heat resisting. Interesting binder constituents are titanium carbide, silicon carbide, zirconium boride, silicon boride and molybdenum disili-

cide. Oxidation-resisting nickel-base titanium carbide cermets have received most consideration for use up to about 1800 F with binder of 50 to 70 per cent.

Table 3—Protective Coatings

1. Ceramic Coatings
2. Molybdenum Disilicide Coatings
3. Metallic Coatings
   a. Cladding
   b. Sprayed metal coatings
   c. Electroplated coatings
   d. Diffusion coatings (cementation)
   e. Hot-dipped coatings
   f. Vapor-deposited coatings
   g. Chromizing

Other cermets of interest include chrome-alumina, molybdenum disilicide, nickel aluminide and metal-bonded Cr_2Ti types. A relatively new group of cermets based on chrome - molybdenum reinforced chromium boride shows significant promise up to at least 2100 F, or alternatively, much higher strength than the carbide cermets at lower temperatures.

Composite materials which become available in foil form will be exploited in sandwich construction, particularly for applications involving exposures to temperatures up to about 1000 F. The relatively inferior efficiency of higher-density alloys such as steel and nickel in columnar buckling and shear emphasizes the importance of resorting to sandwich type construction where these materials are required.

Molybdenum and other refractory wires are being incorporated into titanium by powder metallurgy to create a composite with improved elastic and strength properties at elevated temperatures.

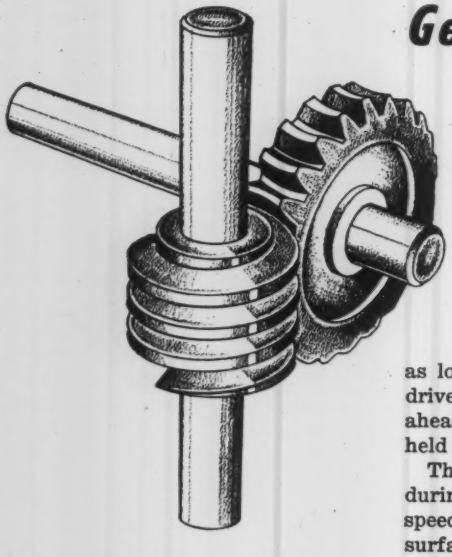
Aluminum-coated glass fiber in an aluminum matrix has been prepared by both vacuum injection and hot pressing. Glass content varies from 20 to 60 per cent depending on the process used. The material is of interest because of its very nearly constant strength at temperatures up to 900 F. Another approach to higher-temperature titanium materials through the use of composites of dissimilar materials is to employ finely dispersed refractory particles in a titanium matrix. Similar work is being done with matrices of molybdenum and nickel-chrome alloys. Results show improvements of at least 20 per cent in stress-rupture strength of molybdenum attributable to addition of 0.1 per cent zirconium oxide by powder metallurgy methods. Titanium carbide additions increase rupture life of 80/20 nickel/chrome at 1500 F.

From a paper entitled "Designing Materials for Future Aerial Vehicles" presented at the SAE National Aeronautic Meeting, New York, April, 1957.

Gear Drive Design

for extreme conditions of speed and load

By Earle Buckingham
Technical Director
Gear Systems Inc.
Boston



AT MODERATE speeds, there are two variations in the intensities of varying load between gear teeth at each engagement. The first takes place when the load is transmitted from a preceding pair of teeth to an engaging pair. The rotating masses must adjust their speeds relative to each other as load transfer takes place. The driven member must be pushed ahead while the driving member is held back.

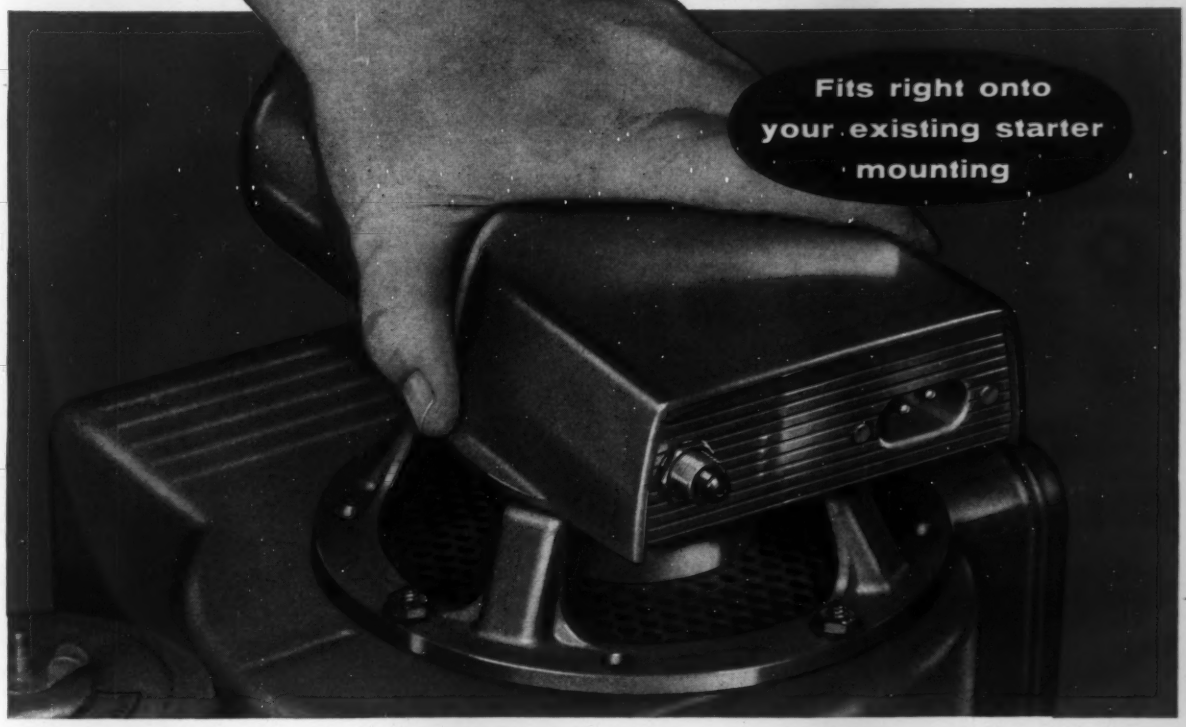
The second takes place when, during tooth separation, relative speeds again change and the two surfaces come together in an elastic impact. The impact load is always equal to, and generally exceeds, the acceleration load.

Acceleration Load: Intensity of the acceleration load, or the force required to accelerate the masses involved, is equal to the product of effective masses and the acceleration. In many respects, these pulsating loads set up by gear tooth action are considered as forced torsional vibrations of the rotating system.

A simple approximation for mass effects of connected rotating masses can be made by determining the load that would twist the shaft or coupling at the pitch radius by an amount equal to the assumed error in the gear drive. This torsional load is added to the acceleration load as established by the product of the other masses and acceleration.

Dynamic Load, Elastic Impact: After the acceleration load has

Now is the time to put pushbutton power starting on small gasoline engines!



Act now to build powerful new sales features into your product

Only six months after our first announcement, large initial orders *prove* that the trend to the Fairbanks-Morse Pushbutton Starter is a fact! Even we were surprised at the fast response — with new emphasis and meaning we now repeat what we said in January: *"Muscles are going out of style for starting small gasoline engines!"*

A Fairbanks-Morse starter, operated by either a 12-volt battery or 110-volt a-c power, fits your rope-started engine just as it is. You simply substitute this powerful new sales feature for your present starters, right on the assembly line. At the same time, the addition of a power source opens the way for electric lights, controls, and other new design ideas and accessories that put your product ahead of the field in performance and sales.

The battery-operated model includes a charger that brings the battery up to full charge simply by being plugged into a 110-volt a-c outlet. The starter itself offers the exclusive design advantages and rugged long service of Fairbanks-Morse Rewind Starters, plus sure-fire pushbutton operation. If your product is powered by a small gasoline engine, and you want to make it more attractive to your dealers and users, send the *coupon* below for our new descriptive bulletin on *pushbutton power starting!*

FAIRBANKS-MORSE

A name worth remembering when you want the BEST

MAGNETOS • REWIND AND ELECTRIC STARTERS • WATER SYSTEMS • GENERATING SETS • PUMPS • MOTORS • SCALES • DIESEL LOCOMOTIVES AND ENGINES

WRITE TODAY for this concise illustrated bulletin offering cutaway photos, detailed drawings, specifications, and application chart — the facts you need to know about today's most important starting device for small gasoline engines.

FAIRBANKS, MORSE & CO.
MAGNETO DIVISION
BELOIT, WISCONSIN

Name_____

Company_____

Street_____

City_____ State_____

ceased to act, the rotating masses of the follower system are moving faster than the average speed, while those of the driving system are moving slower. This causes separation of the contacting surfaces of engaging teeth. Speed of the driving system is increased by its input force and torsional deformation, while the speed of the follower system is decreased by its torsional deformation and working load. When both systems are again running at the same average speed, some of the stored energy in the elastically deformed tooth surfaces is potential.

Extremely High Speeds: It takes a certain amount of time for the double peak load action to occur between mating gear teeth. As the speeds and number of teeth increase for the same number of rpm, the time between successive tooth engagements becomes shorter. Eventually, the time decreases to that which is just long enough for the double peak load operation to take place. Beyond this point, the teeth operate with a single peak load at each engagement.

With increasing speed and shorter time intervals, the effective error in action becomes less. Amount of effective error is controlled by:

1. Intensity of applied load.
2. Magnitude of effective mass acting at the gear pitch line.
3. Time available between successive tooth contacts.

Reducing the circular pitch of the gears reduces proportionately the time interval between successive tooth contacts, which further reduces intensity of dynamic load.

Life Expectancy: Intensities of dynamic loads depend upon initial accuracy of the gears, accuracy of shaft alignments, gear speeds, gear tooth and mounting elasticity, magnitude of rotating masses, and other factors.

Any attempt to predetermine the magnitude of dynamic loads on gear teeth for any application must be of the nature of an estimate. Such estimates form a valid basis of comparison between different designs and selections of materials for a given purpose, but will never tell definitely whether or not a given design will be satisfactory under every condition of service.

Fatigue: Even under good operating conditions, gears may fail because of excessive wear or tooth breakage. Excessive wear is the result of surface loads greater than the materials can carry. Tooth breakage is the result of greater bending stresses on the teeth than the materials can carry repeatedly. Both types of failure, except possibly for a single excessive shock load, are results of material fatigue. The failures are not necessarily related, although tooth breakage may result from excessive wear.

Parts often fail after a time in service when stresses imposed by working loads are less than the ultimate strength or the elastic-limit strength of the material. Repeated loading may result in fatigue failure.

There is some variation in results of endurance and fatigue tests on nominally similar materials. For wrought steels, for example, the average for the endurance limit in reverse bending is close to one-half the ultimate strength of the material. Lower values obtained from these tests are close to one-third the ultimate strength. For one-way bending, endurance limit values are about 150 per cent of those for reversed bending. Hence, for conservative general engineering uses, except when fatigue and endurance tests are made on actual materials, the lower value of one-third the ultimate strength for reversed bending is the safer one to apply in design practice. For one-way bending, the corresponding value is one-half the ultimate strength of the material.

Coefficient of Friction: Tests on gear-tooth friction indicate that the value of the coefficient of friction of approach is double or more that of recess. Possibly, the increase in the value of the coefficient of friction of approach over that of recess is some measure of effort expended during approach in breaking down tooth surfaces.

Resistance to Wear: Conditions for a gear drive that will operate without additional lubricant are:

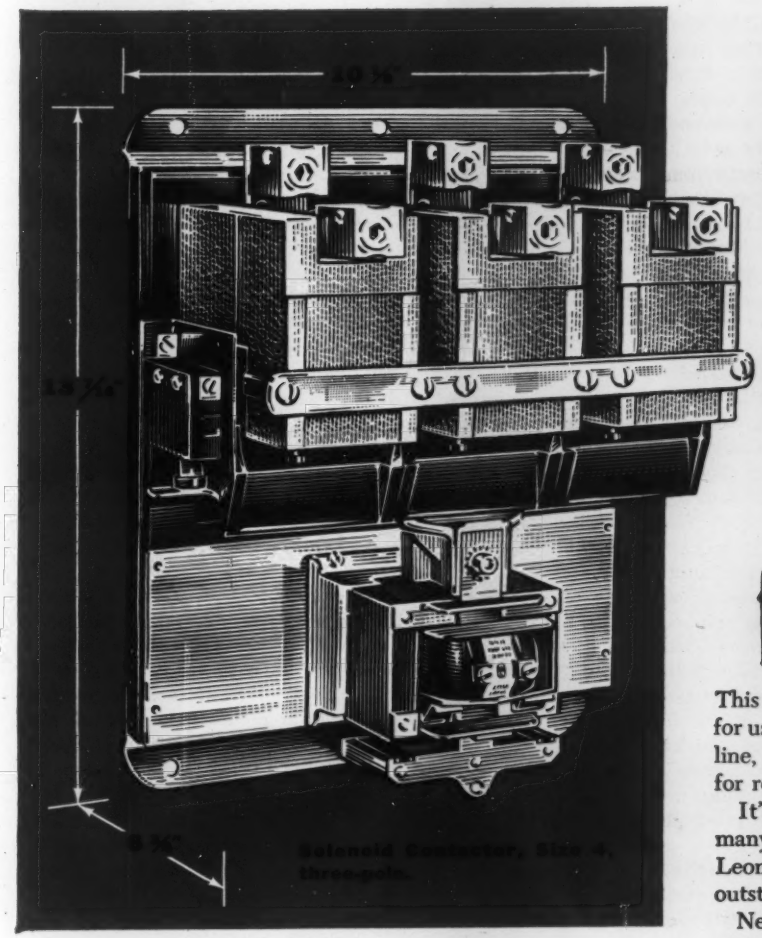
1. Subsurface stresses set up in materials must be kept within surface endurance limits of the materials.
2. Bending stresses at the roots of teeth must be kept within the bending endurance limits of the material.
3. Materials must be sufficiently plastic to cold work in service to develop a smooth, hard surface.
4. Machined surfaces of the teeth must be sufficiently smooth to permit cold working to progress without developing scoring, abrasion or other surface roughening.
5. Action at the tooth mesh must be all recess action. Approach action is a roughening and cleaning one, and recess action is a polishing and smoothing one.
6. Surfaces must receive adequate and persisting surface-contamination treatment.

Reducing Mass Effects: For high-speed drives in particular, every effort should be made to reduce the value of effective mass acting at the mesh. One way to accomplish this is with a torsion bar of sufficient length to give a torsional deflection of 0.001 or 0.002-in. at the pitch radius of the gears. The diameter of the torsion bar must be large enough to carry working loads without too high a stress. If the initial diameter is increased to accomplish this, the length of the torsion bar must be increased sufficiently to obtain the same torsional deflection and torque.

On extremely high-speed drives, critical speeds cannot be avoided. In such cases some simple and effective damping means must be used. Energy of these torsional vibrations is low enough so that a small amount of friction will absorb most of it, to prevent it from building up to a dangerous degree.

Natural torsional vibrating periods of several elements of the rotating systems should be determined. None of them should be synchronous or harmonic in relation to another.

Alignment of Gear Axes: Errors in shaft alignment can alter an almost-perfect pair of spur or helical gears into an imperfect pair of bevel or hypoid gears. Shaft



Solenoid Contactor, Size 4, three-pole.

NEW 150-amp solenoid contactor extends proven line

This new Size 4 A.C. solenoid contactor is ideal for use in motor starters and controllers for main line, accelerating and reversing purposes and for resistance heating and lamp loads as well.

It's the new Bulletin 4454—incorporating many advanced design features found on Ward Leonard's Sizes 0 to 3 contactors. Check these outstanding features:

New sintered-silver-cadmium-oxide contacts—can repeatedly handle high inrush currents without a sign of contact welding, excessive pitting or other damage.

Simple, compact solenoid design—excellent for modern metal control panels using accessible front-of-board wiring, particularly useful where panel space is limited.

Available with two or three main poles and up to 4 side-mounted auxiliaries. Also with provision for mechanical interlocking and addition of overload relays.

Completely described in Bulletin 4454. Write for your copy today. The Ward Leonard Electric Co. 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada Ltd., Toronto.) 7.6

ENGINEERING DATA

Size 4 A.C. Contactor Ratings*

Service	8-Hour Ampere Rating		Enclosed Power Rating	
	Open	Enclosed	Three Phase Volts	H.P.
Across-the-Line Starting	150	135	110 220 440-550	25 50 100
Across-the-Line Plug-Stop or Jogging	150	135	110 220 440-550	15 30 60

Service	8-Hour Ampere Rating	Single Phase Volts	Single Phase K.W.	Three Phase Volts	Three Phase K.W.
Resistive Heating Load**	150	110 220 440 550	15 30 60 75	110 220 440 550	26 52 105 130
Tungsten Lamp Lighting or Infrared Heating Load**	120 Amperes for 250 Volt Circuits or Less				

*The ratings listed are those recommended by the National Electrical Manufacturers Association.
**These ratings apply to open or enclosed contactors.

LIVE BETTER...*Electrically*

Circle 456 on page 19

misalignment is probably responsible for more noisy, short-lived, and generally unsatisfactory gear drives than gear errors themselves.

No individual gear has pitch surface. Pitch surfaces exist only when two gears are meshed. Then, for both size and form, they depend entirely upon conditions of position and alignment of the axes upon which they rotate. If these change under varying conditions of load, pitch surfaces change accordingly.

Different types of gears and their forms of pitch surfaces can best be classified according to alignment conditions of the shafts on which they are mounted.

Parallel Shafts: Pitch surfaces of gears mounted on parallel shafts are cylinders. If the axes of rotation are not parallel for any reason, the pitch surfaces assume the form that the actual alignment of their axes impose upon them.

Tooth forms for gears mounted on parallel shafts may be straight spur or helical teeth, external or internal.

Shafts with Intersecting Axes: Pitch surfaces of gears mounted on intersecting axes are cones unless the shafts deflect under load so that the point of intersection shifts. If such is the case, actual pitch cones will be different from the assumed cones for which the gears were designed.

Tooth forms for gears mounted on intersecting axes may be straight tapered, curvex or spiral. In addition, a straight spur or helical pinion may be meshed with a properly generated face gear, and their pitch surfaces are cones.

Nonparallel, Nonintersecting Shafts: When gears are mounted on nonparallel, nonintersecting shafts, any one of several conditions may be set up depending upon some of the geometrical properties of tooth forms used.

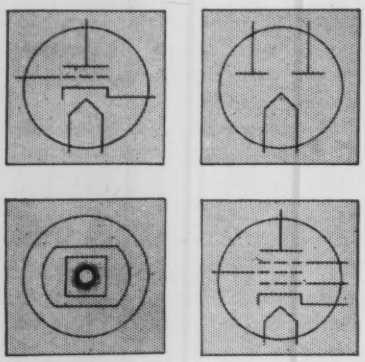
When the teeth of both gears have a uniform axial lead, both members of the pair have a pitch plane and pitch cylinder. Contact between teeth is point contact which limits their load-carrying ability. Within the limits of their capacity, they are about the best behaved and most satisfactory type of gear. By designing a pair of spiral gears with pitch planes shifted almost to their root diameters, a type of gear results that can be made to have all-recess action running in both directions.

Spiral and Worm Gear Drives: Some gear drives in this category use a tapered worm which meshes with a generally conical face gear. Lead of the threads of the worm will be different on the two sides of the worm thread. The action here is true worm-gear action.

In addition, there is a wide variety of hour-glass worm drives where the smaller driving member partially envelops the larger or gear member. Some of these are true worm drives. Others have no definite pitch surfaces or conjugate gear tooth action, but act as barrel cams driving a multi-toothed follower.

For all of these types of gears, if the master or controlling member is made of a harder material with smooth thread or tooth surfaces, and its mate is made of softer and more plastic material, minor misalignments or deflections of shafts by cold-forming the mating surfaces in actual operation will be taken care of automatically. When both members are hard, all of the accuracy of operation must be built into them.

From a paper entitled "Design of Gear Drives for Extreme Conditions" presented at the 41st Annual Meeting of the American Gear Manufacturers Assoc. in Hot Springs, Va., June, 1957.



Trends in

Electronic Component Design

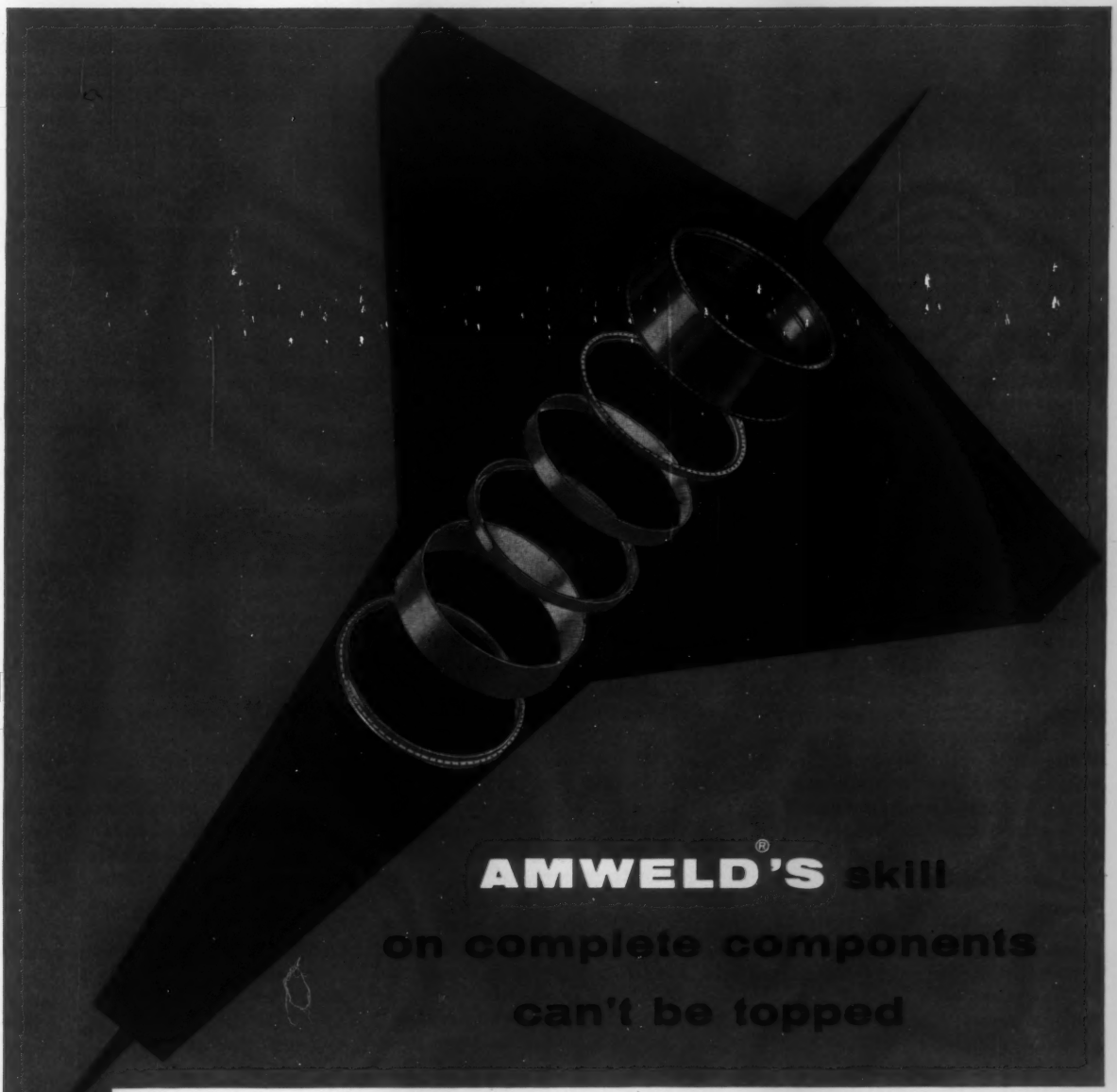
By W. I. Bull

Capt., USN
Assistant Chief for Electronics
Bureau of Ships
Department of the Navy
Washington, D. C.

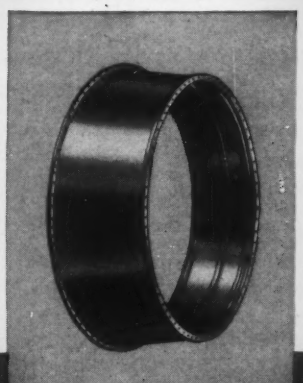
THOSE responsible for design of new electronic components cannot wait until the engineer designing a system places a specific demand upon them for a component of certain characteristics. The cycle of time from initial development or material discovery to electronic component availability often takes close to 10 years.

Design Problem: Temperature is the most serious problem affecting efficiency today. When heat-generating components are packed into a small space, environment is created with an intolerable ambient temperature. Since there is need to pack more equipment into limited spaces, the space problem can be overcome only by making packages smaller. This, in turn, creates a need for more efficient components.

Need for parts to operate at higher temperatures outweighs requirements for ability to withstand



AMWELD® skill on complete components can't be topped



As a supplier of welded rings and components to major United States jet engine manufacturers, American Welding has proven its skill as part of an industry where cost and precision are vital factors. As the missile and rocket programs grow from the experimental to the production stage, Amweld's experience and skill can play a part in these essential programs.

If you have a problem that can be solved by a rolled and welded ring or component, or any welded fabrication, contact American Welding's Industrial Products Division. Their skill, experience, and engineering are at your service.

THE AMERICAN WELDING & MANUFACTURING COMPANY
130 DIETZ ROAD WARREN, OHIO

AMERICAN WELDING
The World's Leading Manufacturer of Welded Rings

greater shock, vibration and humidity. Reference is not to operation at momentary temperature peaks, but to operation in a steady, high-temperature environment for the required period of reliable performance.

Today, a temperature range of −55 to +125C (−67 to +257F) is the range over which all parts can be expected to operate continually at rated values. This performance is obtainable in high-quality parts but, even at these temperatures, some parts operate marginally even though they do meet requirements. For example, rectifier performance, with the exception of silicon, is marginal at high temperatures, and the supply of silicon rectifiers is limited. Dry batteries are quite deficient, and conventional fixed-composition resistors are impossible to use at extreme temperatures.

An interesting relation between temperature and reliability was shown recently with general-purpose planned position indicators. Some units were operated under ambient temperature conditions in normal, average installations. Other units were operated in relatively the same environment, but were modified for additional cooling. Cooling brought the temperature down about 30 deg (C). As a result of the temperature drop, removal rate per 100 hr for tubes was improved by a ratio of 3 to 1, and the mean time between overall malfunctioning of the equipment, by a factor of almost 2 to 1. In general, a 20 deg (C) drop in ambient temperature doubles the reliability of a piece of equipment.

Most new part development programs require a lead time of at least 2 yr over associated equipment development schedules. To support this estimate of time, consider the relatively small number of operational equipment designed around the transistor.

Future Approach: When present-day component parts are analyzed in an attempt to evaluate problems at high temperatures, the conclusion is that there is need for development of new insulating materials, i.e., conductive alloys and piezoelectric, semiconductive, and new materials with special magnetic properties and dielectric constant.

Costs resulting from problems concerning component heating are extremely high. For example, 15 lb of cooling equipment are needed for each kw of power generated by airborne electronic equipment. Considering weight, fuel and powerplant requirements, a jet fighter with a 6-kw load must carry 154 lb of cooling equipment which boosts the weight of the plane by 1540 lb. At present prices, the cost of the fighter is increased $60,000.

Semiconductor devices are of interest for the future to keep self-generated heat down. Although semiconductors themselves have a temperature limitation, silicon appears to be the answer. Even if these temperature limitations are overcome, a full line of parts to exploit advantages of the transistor will be needed.

Ceramic tubes have operated at temperatures in excess of 500C (932F). This characteristic alone poses a challenge to the designer. Types of parts that may be required to complement the transistor are pertinent.

Capacitors: Main differences between types of capacitors needed for transistor circuits and those now used for electron-tube circuits are in capacitance values and the lower working voltage range (5 to 50 v dc) required for transistor circuit types.

Capacitors required for transistor circuits are divided into five classes:

CLASS 1: Low-frequency application types with capacitance values from 1 to 20 mfd and tolerances from −10 to +50 per cent. Available tantalum electrolytic types of capacitors now meet Class 1 needs up to 115C (239F).

CLASS 2: Wide tolerance capacitors with characteristics similar to those in Class 1 except that required capacitance ranges from 20 mfd to thousands of mfd.

CLASS 3: Capacitors with capacitance values from 1 to 10 mfd and ±10 per cent tolerance, stability to within 0.02 per cent per deg C, and capacitance retrace values within 0.5 per cent.

CLASS 4: Low capacitance units required to have 1 to 2 per cent capacitance tolerance and a stability three to four times better than that of Class 3. Capacitors that now meet these electrical requirements are practically all mica-dielectric types that are too large for transistors.

CLASS 5: Precision types of the order of ±0.5 per cent with electrical characteristics equal to or better than the silvered-mica capacitors which are presently too large for transistor circuits.

Inductors: Inductor characteristics required for transistor circuits range in value from 1 mh to 100 h with 10 to 20 per cent tolerance.

Resistors: In general, transistors will require the same types of resistors as those in electron tube circuits except that resistors will be smaller. Resistors fall into three main classes: general purpose, precision and power.

In the general purpose class are resistors of 0.1-w rating or less, with the finished resistor having wire leads of not more than 10-mil diam.

In the precision class, values from 1 to 100,000 ohms are required with permissible change from aging limited to 1 per cent.

In the power class, requirements are for better heat sinks, possibly metal-cased types of resistors.

Design Changes: Fabrication techniques undoubtedly impose needs for changing part designs to eliminate the following undesirable mechanical characteristics:

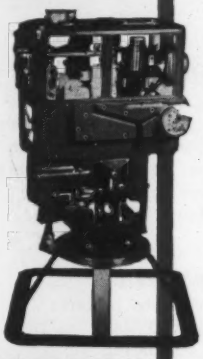
1. Wire lead terminals that vary too widely among part categories in diameter, length and stiffness.
2. Leads of transformers and crystal diodes not properly polarized.
3. Parts that are not proportioned in modular steps of length.
4. Too few parts designed with rectangular cross-sections for maximum packing efficiency in packaged subassemblies.

Trends seem to be toward a sandwich construction, or long, thin units with printed circuit cards as basis, making possible automatic assembly. Also, better printed-circuit board material is needed.

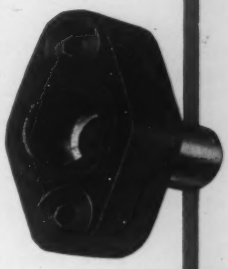
From "Future Demands on Component Design" in Bureau of Ships Journal, *April,* 1957.

5 practical ways to "streamline"

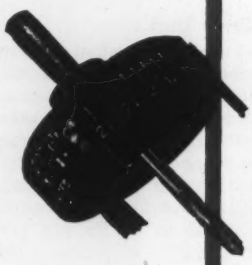
...without sacrificing fastening strength



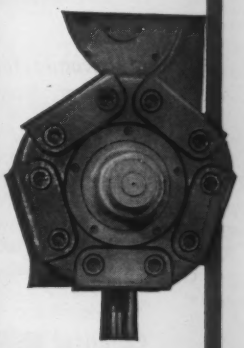
1. Counterbored holes are the simplest approach to flush surfaces using standard socket cap screws. The advantage of specifying genuine Allen O Head Cap Screws is the greater strength of Allenoy steel... you can use smaller sizes for closer spacing and reduced weight. Call on Allen, too, for *very large* socket-head, precision cap screws — up to 2½ inch diameter.



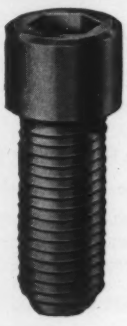
2. Countersinking enables you to get absolutely smooth external surfaces using Allen O Flat Head Cap Screws. Allen O Cap Screws feature the exclusive Leader Point which makes screw starting easier and guards against thread damage.



3. Button Head Cap Screws produce snag-free unbroken surfaces where countersinking is impractical. Button-head hex sockets are necessarily shallow. In genuine Allen O Button-Head Cap Screws, sockets are cold forged without broaching, in extra strength Allenoy steel... essential protection against stripping the sockets under high torque pressure.



4. A ready made hole tapped in forged steel solves many a design problem. It's called the Allenut. It can be anchored in soft material to assure durable threading, or recessed to permit tightening with an Allen Hex Key.



5. Bright finish, or rust and corrosion resistance call for Allen O Stainless Steel Cap Screws. They are standard stocked items (both NF & NC threads) readily available in a wide range of sizes from Allen Distributors.

YOUR ALLEN DISTRIBUTOR can give you practical help and swift service. For complete information on any technical fastening problem, write our engineering department direct.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

Hartford 2, Connecticut, U.S.A.

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Coil & Sheet Slitters

"Multiple Rotary Slitting Lines" is title of illustrated reference handbook on all types and sizes of Yoder slitters and allied equipment. Covered are design, selection and operation of slitters and slitting lines; time studies and analysis of operating cycles; discussion of coil handling and scrap disposal methods; and other operating data. 76 pages. Yoder Co.

Circle 571 on page 19

Spiral Bevel Gears

Revised data on the Gleason spiral bevel gear system, adopted by the AGMA in 1922, is contained in bulletin SD 3006C. Complete design information and formulas are included. 12 pages. Gleason Works.

Circle 572 on page 19

Polyethylene

Technical bulletin C-6-216 contains complete design and application information on Super Dylan polyethylene. Material is reported to have good heat resistance, high tensile strength, excellent low-temperature impact strength, rigidity, good chemical resistance, low permeability, light weight and attractive appearance. Processing and fabrication guidance is given. 20 pages. Koppers Co., Chemical Div.

Circle 573 on page 19

Lubricant Tester

Revised to incorporate new operating information on the model LFW-1 Lubricant - Friction - Wear testing machine, bulletin 106 includes a revised list of specifications in the English and Metric systems. 2 pages. Alpha Molykote Corp.

Circle 574 on page 19

Thermocouple Tubing

Constantan, Chromel-P and Alumel special analyses and standard ingot iron thermocouple tubing are subject of Special Analysis Memo No. 118. It presents chemical composition, mechanical properties, physical properties, applications, production limits and standard tubing tolerances for these four materials as they relate to small tubing. 3 pages. Superior Tube Co.

Circle 575 on page 19

Beryllium Copper Parts

Physical, electrical, chemical, formability, tolerance and stress charts and data on beryllium copper components as well as detail of standard and special parts made to users' specifications are included in revised catalog. 12 pages. H. Braun Tool & Instrument Co.

Circle 576 on page 19

Regulated Power Supplies

Filament, telemetering and strain gage, computer and miniature magnetic amplifier power supplies are subject of illustrated catalog. Included is discussion of transistorized direct current regulators and inverters. 4 pages. Gulton Industries, Engineered Magnetics Div.

Circle 577 on page 19

Multiconductor Cable

"Design Engineering Specification PAP-C-101" is written for designers and engineers having need for neoprene-jacketed multiconductor electronic cables. Materials, construction, specifications, performance and other data are given on correct cable for specific electronic applications. Pacific Automation Products, Inc.

Circle 578 on page 19

Chemical Milling

How blueprints that contain all essential information can save time and money in fabrication of tooling and at every chemical milling manufacturing step is explained in bulletin No. 5. Entitled "Blue Prints for Parts to be Chemically Milled," it applies to aluminum, magnesium, stainless steel and titanium parts. United States Chemical Milling Corp.

Circle 579 on page 19

Weld Fasteners

"Ohio Weld Fasteners—the Primary Fastener in Fastener Assemblies" is title of guide for design and production engineers concerned with metal fabrications and assemblies. Described are ten types of Weld Nuts which are applied by resistance welding. Also detailed are brackets, bosses, clips, pads, knobs and handles for resistance welding application. Levelers and adjusting screws are covered. 40 pages. Ohio Nut & Bolt Co.

Circle 580 on page 19

Epoxy Adhesives

Illustrated bulletin entitled "Properties Chart—Epibond Adhesives and Epocast Pastes" is a guide to the application of epoxy adhesives in wide range of industries. Furane Plastics Inc.

Circle 581 on page 19

Filtration Sheets

New products bulletin No. 6 presents technical data on new line of products consisting of Teflon resin as fibrous sheets for filtration and other uses. E. I. du Pont de Nemours & Co.

Circle 582 on page 19

Cycling Drive Unit

Clutched starting, braked stopping, sensitive inching, accurate positioning, interim holding, selective acceleration and deceleration, and safety torque limiting are some of the functions performed by the Cycledyne. Additional data on the electro-magnetic cycling drive unit with outputs from fractional to 75 hp are given in bulletin CD-557. 12 pages. Cycledynamics Inc.

Circle 583 on page 19

Industrial Liquid Meter

Described in illustrated bulletin 94/10 is the new Neptune stainless steel liquid meter for measuring corrosive liquids. Cut-away view of this meter shows design and operating features. Liquids that can be handled safely are listed. 4 pages. Neptune Meter Co.

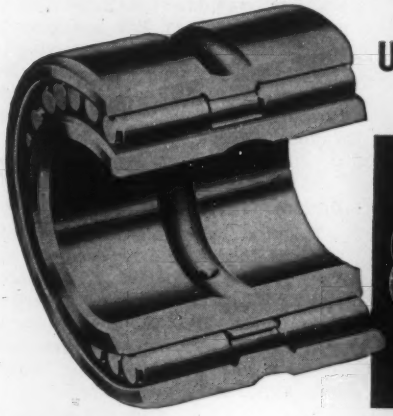
Circle 584 on page 19

Timers & Relays

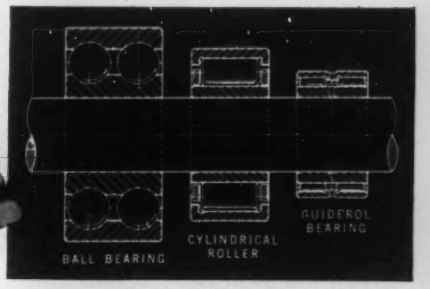
Combination catalog-manual contains an initial issue of 25 engineering bulletins on repeat cycle timers, time delay relays, elapsed time indicators, stop clocks, electric and chronometric governed timing motors and relays. Charts, diagrams

BEARING TIPS by McGill

To pack more performance in smaller space



Use space-saving McGILL GUIDEROL® needle bearings

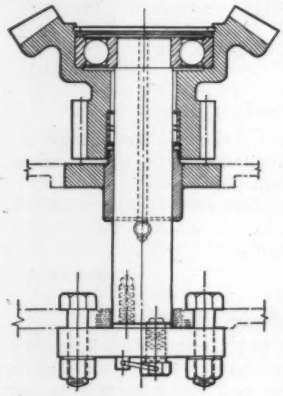


Showing graphically how a McGill GUIDEROL precision needle bearing permits more streamlined designing by supporting comparative loads in significantly smaller radial space than other types of bearings. Bulky and more costly housing space is easily avoided.

The McGill GUIDEROL Bearing combines the inherent high-load capacity of a full complement of full race width rollers with a center roller guiding principle that limits skewing and binding under misalignment. This qualifies the bearing for a whole range of applications that are too heavily loaded for a retainer-type bearing and are subject to the misalignment that precludes use of an ordinary needle bearing. For outstanding performance in small radial space, use GUIDEROL precision needle bearings. Specify the interchangeable sealed SGR series for added protection against contamination.

GUIDEROL® *bearing capacity, space economy proved in power shovel vertical reversing shaft assembly*

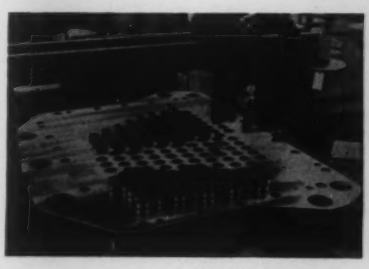
Baldwin - Lima - Hamilton Corp. uses a McGill GUIDEROL bearing, on ½ cubic yard power



shovels, to carry spur pinion loads in the vertical reversing shaft. The high capacity of the bearing in small radial space is an important factor in selection of this bearing. Only 3.75″ in diameter, it has a load capacity of 28,560 lbs. at 100 rpm. In the power shovel application, it supports 14,150 lbs. at 76.3 rpm, which gives a high margin of safety. The center guided rollers also are especially adaptable to a vertical application such as this.

Fact-packed Bearing Catalog

Write for your copy of Catalog #52-A, a 128 page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.



Multiple spindle drill heads require support of spindles on very close centers

Crowding a great number of drill spindles into a small area, Zagar, Inc., of Cleveland has found the McGill GUIDEROL bearing construction especially suited to the needs of multiple drill head units. The full bearing width rollers provide rigidity and more than adequate load capacity and in a bearing only 1.25″ in bore diameter.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

and technical data aid designers. Provision is made for inserting new or revised bulletins. A. W. Haydon Co.

Circle 585 on page 19

Electrical Connections

Procedure for friction tinning of aluminum is explained in instruction sheets. Also available are bulletins 1 to 10 which explain techniques and wire stripping equipment used to insure reliable electrical connections. 4 and 12 pages, respectively. Eraser Co.

Circle 586 on page 19

Pressure Pickup

Specifications and application data are given in bulletin CEC-1573 on the type 4-340 dynamic pressure pickup. This has a frequency response range of 3 to 250,000 cps and operates in a pressure range from vacuum to 100 psi. 2 pages. Consolidated Electrodynamics Corp.

Circle 587 on page 19

Water & Steam Hose

Two catalog sections present operating data on five types of water suction hose for industrial application and on five types of steam hose. 4 and 2 pages, respectively. B. F. Goodrich Industrial Products Co.

Circle 588 on page 19

Thermocouple Assemblies

Catalog No. 1556 explains features of bare wire thermocouple glands, sealants and insulators, wells, Teflon and stainless protected units, quick-disconnect thermocouples and many other thermocouples and accessories. 28 pages. Conax Corp.

Circle 589 on page 19

Drawing-Blueprint File

The Dancer Stikfile system for filing blueprints, drawings, plans, tracings and other large reference sheets is described in illustrated broadside. Sizes and capacities are available for every engineering department need. 8 pages. Dancer Stikfile Co.

Circle 590 on page 19

Potentiometer

Linearity tolerances as close as ±0.05 per cent can be provided in series AJ precision potentiometers described in data sheet 54-07. These ten-turn controls have resistance ratings from 25 to 100,000 ohms. 2 pages. Beckman/Helipot Corp.

Circle 591 on page 19

Electrical Relays

Machine tool, direct current, light duty, timing, thermal overload protection, electronic and thermostatic relays and their use in automated equipment are subject of illustrated bulletin B-7073. Capsule descriptions are given on typical controls in each category. 12 pages. Westinghouse Electric Corp.

Circle 592 on page 19

Variable Speed Drives

Single groove variable-flange sheave of the Dayton variable speed drive can accommodate Q, R, and W cross-section cog belts to give a wide selection of speed ratios, driven speed ranges and center distances using motors rated up to 20 hp. Design information is included in catalog VSD-11. 8 pages. Dayton Rubber Co.

Circle 593 on page 19

Precision Switches

Applications of Micro Switch precision switches as limits, indicators and interlocks are discussed in illustrated folder. Brief details are given on UL-approved explosionproof switches. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 594 on page 19

Plug-in Busway

Designed primarily as feeders for lighting service and power loads, type FVK plug-in busway is suitable for 2 and 3-pole, 600-v, 3-phase, 4-wire and 3-phase, 4-wire, 480Y/277-v applications. Performance and application data are given in bulletin GEA-6470A. General Electric Co., Distribution Assemblies Dept.

Circle 595 on page 19

Leaded Alloy Steel

Up to 200 per cent greater output for machined parts is reported when using Rycut 40 leaded alloy steel as compared with a similar analysis material without the lead addition. Properties and advantages of this material are outlined in bulletin 14-5. 8 pages. Joseph T. Ryerson & Son, Inc.

Circle 596 on page 19

Oil Seals

Information on how to select the right shaft seal is found in illustrated spiral-bound bulletin S-102. Specifications on many types of cased and bonded rubber oil seals are included, along with engineering, installation, design and other data. Common causes of premature oil seal failure are presented. 100 pages. Albert Trostel Packings, Ltd.

Circle 597 on page 19

Electrical Connectors

R and RL electrical connectors for use in aircraft, radio and many types of instruments and general electrical equipment are detailed in catalog K6. They are available in seven basic shell types having 8 insert sizes, totaling more than 220 arrangements with a variety of amperage and voltage ratings. 64 pages. Cannon Electric Co.

Circle 598 on page 19

Aircraft Thermocouples

The four basic junction tips available in thermocouples designed for aircraft gas turbines and related aviation applications are described in bulletin MC-153. Performance data are given on wires for temperatures to 2000° F. 4 pages. Fenwal Inc., Aviation Products Div.

Circle 599 on page 19

V-Belt Drives

Tips on how to obtain longer V-belt life are contained in bulletin 20X6234C. Various types of V-belts are described, together with selection and matching guidance. Common causes of V-belt destruction are portrayed. 12 pages. Allis-Chalmers Mfg. Co.

Circle 600 on page 19

Adjustable Thermostat

Bulletin RT-807 contains complete information on an electric thermostat that automatically switches from high to low heat on equipment where two heating elements are used. Temperature ranges are available up to 800° F. 4 pages. Robertshaw-Fulton Controls Co.

Circle 601 on page 19

Electric Coils

Relay and solenoid type coils described on data sheet operate efficiently at −68 to 260° F. Design features and specifications are included. 1 page. Tur-Bo Jet Products Co.

Circle 602 on page 19

Cadmium Brightener

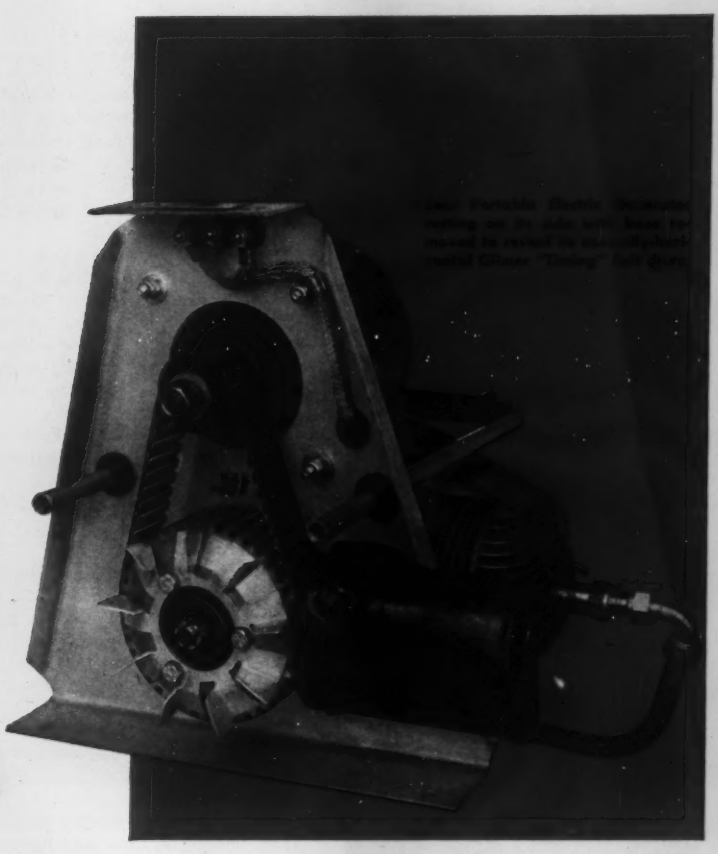
Cad-Kote cadmium brightener used in a plating bath provides nuts, bolts, tools and other parts with corrosion protection. Suited for still and barrel plating, it is described on data sheet. 1 page. SmootheX Inc.

Circle 603 on page 19

Stainless Steels

Information on how to machine popular stainless steel grades is found on a pocket-size slide chart. Data on turning, drilling and other

Required: 12,000 rpm... and only a Gilmer "Timing" Belt drive met the need... with lightness and compactness



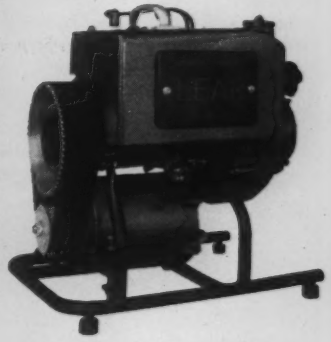
BUILT TO serve as a lightweight, foolproof source of emergency or auxiliary electric power, this new Lear Portable Electric Generator is a miracle of efficiency. Helping to make that miracle possible is the Gilmer "Timing®" Belt drive which Lear chose for the vital job of transmitting the power of the 3 hp. gasoline engine to the high-speed alternator.

This bantam power supply, occupying only 1½ cubic feet and weighing as little as 35 pounds, produces up to 1500 watts AC or 1350 watts DC. To achieve such efficiency the alternator is designed to operate at approximately *three times* the engine's 4000 rpm speed, or nearly 12,000 rpm! This means that the belt must travel at almost a mile a minute, even though very small-diameter pulleys are used.

For such an application no other type of drive of equal capacity can match the "Timing" Belt's lightness of weight, compactness, and ability to transmit full power at such high speed without slippage, without lubrication and without take-up or other maintenance! Lear's own literature points up these additional facts:

"Selected for its high efficiency, the flat tooth-belt drive assures a long, dependable operating life for both engine and alternator due to reduced radial bearing loads which this particular drive allows*. The belt is steel-cable-reinforced and will give long life and trouble-free service."

Your local NYB&P-Gilmer Distributor stocks standard "Timing" Belts and pulleys and will gladly help in obtaining special sizes you may require for original equipment. Consult your classified telephone directory for his name.



Larger 3500-watt Lear unit employs a compact 2"-wide Gilmer "Timing" Belt drive.

**Positive tooth grip replaces friction grip, eliminates need for initial belt tension, lightens bearing loads.*

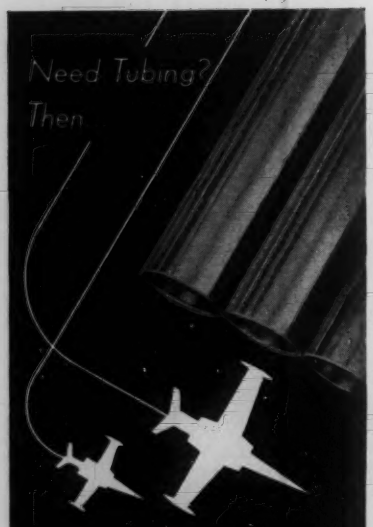
Gilmer **V-BELTS AND "TIMING®" BELTS**

NYB&P INDUSTRIAL RUBBER PRODUCTS

NYB&P — Founded 1846 — NEW YORK BELTING & PACKING CO.

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

Proving for 111 years that QUALITY COSTS LESS!



Look No Further For Quality...

Because *BISHOP* small diameter tubing is not excelled in accuracy of I.D. and O.D. . . . in dimensional precision . . . in tolerances . . . in finish.

Whether it be for a precision part in an instrument . . . a heat exchanger in today's high speed aircraft . . . a thermocouple . . . an electronic or atomic application.

Wherever tubing is needed to meet corrosion, heat, shock, stress, psi pressure resistance and vibration . . . for highest quality and performance specify BISHOP tubing, at comparable prices.

SEAMLESS AND WELDED AND DRAWN STAINLESS STEEL TUBING

Mechanical, Capillary, Hypodermic and Aircraft Grade

(.008" to 1.000" O.D.— .003" to .083" Wall)

NICKEL AND ALLOY TUBING

(up to .625" O.D.)

TUBULAR FABRICATED PARTS

Flanged, Flared, Milled, Slotted, Swaged and Threaded

GLASS-TO-METAL SEALING ALLOYS

CLAD METALS & COMPOSITE WIRES

Catalogs on Request. For Prompt Service, Fast Deliveries Call Malvern, Pa. 3100

JB

J. BISHOP & CO. Platinum Works

Stainless Steel Products Division, Malvern, Pa.

Circle 461 on page 19

Helpful Literature

machining operations, plus material's workability in blanking, drawing, forging, roll threading, welding and other operations are included. Carpenter Steel Co.

Circle 604 on page 19

Oil Seals

Catalog 856-C contains illustrations and information on all stocked C/R oil seals. Properties of various seal materials used to satisfy specific service requirements are listed. Included is engineering data section on shaft materials, finish, hardness, shaft size and tolerance, speeds, pressure and lubrication. 68 pages. Chicago Rawhide Mfg. Co.

Circle 605 on page 19

Liquid Chillers

Flow-therm packaged liquid chillers, subject of illustrated catalog 533, are offered in nine ratings from 20 to 125 tons. They become heat pumps with factory-installed changeover valves. Engineering data and selection table are included. 16 pages. Acme Industries, Inc.

Circle 606 on page 10

Tank Heaters

Selection of the proper Hydro-Flow tank heater or tank and heater combination is facilitated by illustrated engineering bulletin HK-456. Heating of water is with steam or water. Ratings and specifications are given. 6 pages. Bell & Gossett Co.

Circle 607 on page 19

Hardness Testers

Methods and machines for Brinell hardness tests are described in illustrated folder A-15. Images of ball impressions are projected on a built-in ground glass screen of the motorized reflex type machine. Operating details are presented. 4 pages. Gries Industries, Inc., Testing Machines Div.

Circle 608 on page 19

Electrospark Machining

Explanation of the Method X process of electrospark machining is found in bulletin 43373, along with specifications and details of style 243-6 vertical machine. It makes a cavity in any electrical conducting material. Ex-Cell-O Corp.

Circle 609 on page 19

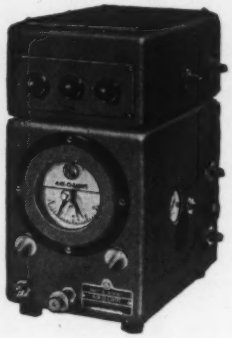
Wet Mixing Equipment

Three types of Eppenbach mixers and homogenizers detailed in catalog 600 are colloid mills for refining wet materials to fine size, Homo-Mixers for fast blending of light to heavy

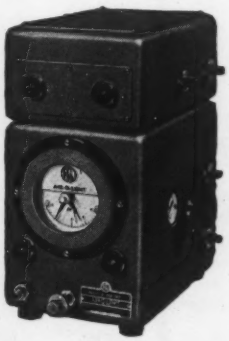
BUILD A GAGE INSTALLATION TO SUIT YOUR NEEDS . . .

with these packaged, on-the-shelf P&W Air-O-Limit Light Signal Units. Can be used to signal operator or to provide feed-back impulse for fully automatic process control.

BASIC 2-LIMIT UNIT . . . indicates high and low tolerances. Suitable for sorting and other "yes-or-no" control applications.

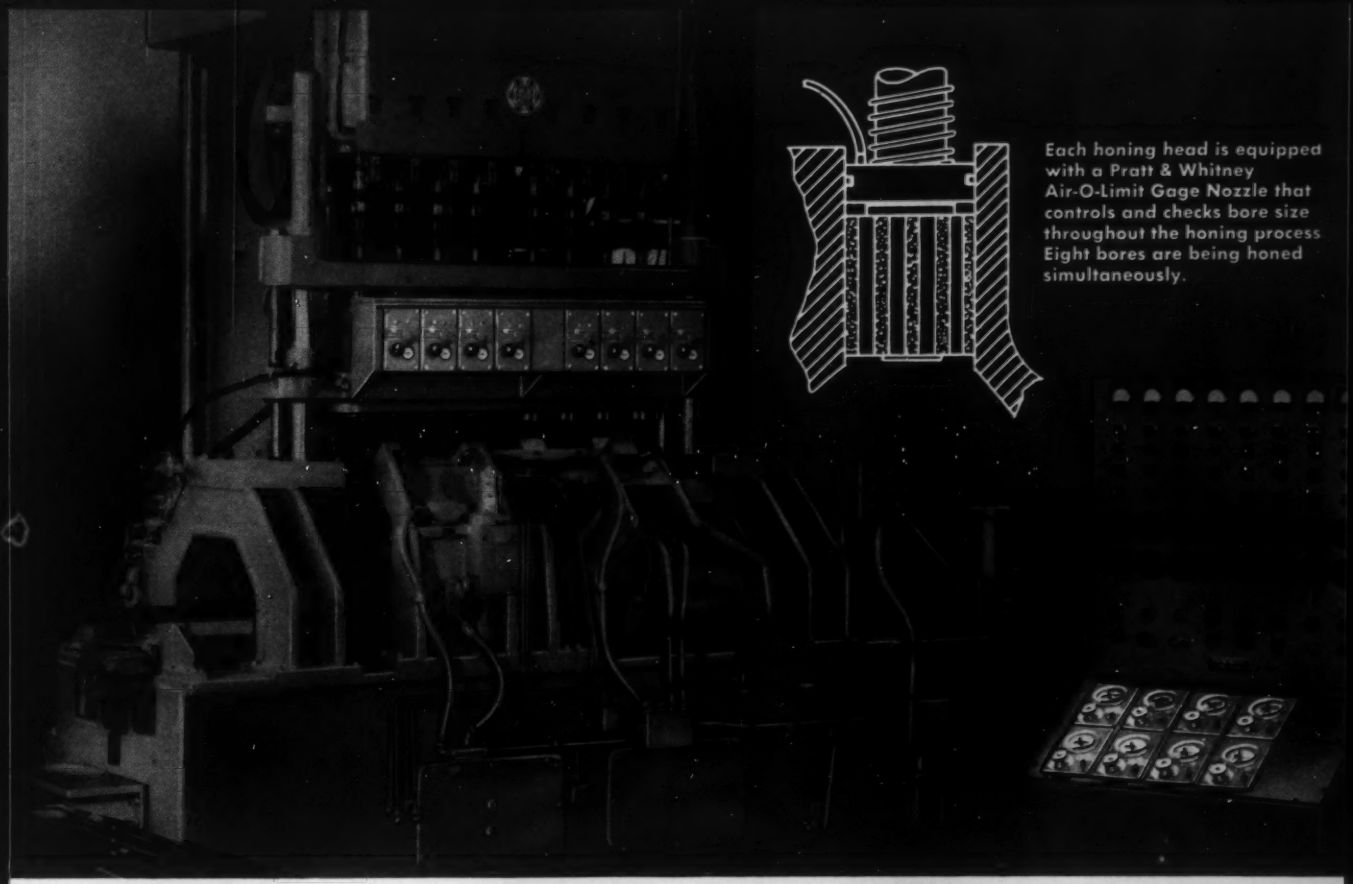


3-LIMIT UNIT . . . especially suited for grinding and similar operations. Indicates or automatically controls such conditions as: "Fast Feed," "Slow Feed," and "Spark-Out."



4-LIMIT UNIT . . . similar to 3-Limit Unit, but provides greater control scope. Indicates or controls such conditions as: "Approach High Limit," "High Limit," "Approach Low Limit" and "Low Limit."

Circle 462 on page 19



Each honing head is equipped with a Pratt & Whitney Air-O-Limit Gage Nozzle that controls and checks bore size throughout the honing process. Eight bores are being honed simultaneously.

PHOTO COURTESY OF MICROMATIC HONE CORPORATION, DETROIT, MICH.

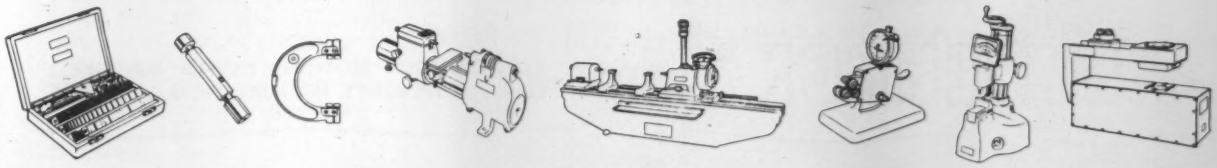
Design Higher Production into Your Machines THE EASY WAY

• • • • WITH PRATT & WHITNEY "PACKAGED" AUTOMATION GAGE UNITS

Pratt & Whitney "Automation Gaging" is fully automatic control of product size by means of "feedback" impulse from automatic gages to the machine. Applied to your designs, Automation Gaging can help you provide performance standards that will increase production rates, reduce scrap losses and take full advantage of the high precision built into your machines. In addition, Pratt & Whitney standard, on-the-shelf Packaged Gage Units provide an installation *custom-tailored* to your design requirements *without* the expense and delays involved in engineering and constructing special controls.

In this example – a Micromatic Hydrohoner – automotive cylinder blocks are gaged *during* the Microhoning process. When final size is reached, the machine is automatically shut off and the Microhoning tools are retracted. A change to a different bore size can be made without stopping the machine, by a simple adjustment on a calibrated gage control dial. Visual indication is given of the accuracy of the new adjustment. Cylinder blocks are produced at a rate of 120 per hour. Reject and scrap losses are virtually eliminated.

Call in a P&W Field Engineer to analyze your requirements and recommend the right P&W Automation Gaging installation to meet your needs exactly. Pratt & Whitney Company, Incorporated, 33 Charter Oak Boulevard, West Hartford, Connecticut.



GAGE BLOCKS . . . CONVENTIONAL GAGES . . . SUPERMICROMETERS . . . STANDARD MEASURING MACHINES . . . COMPARATORS . . . AUTOMATION AND CONTINUOUS GAGES

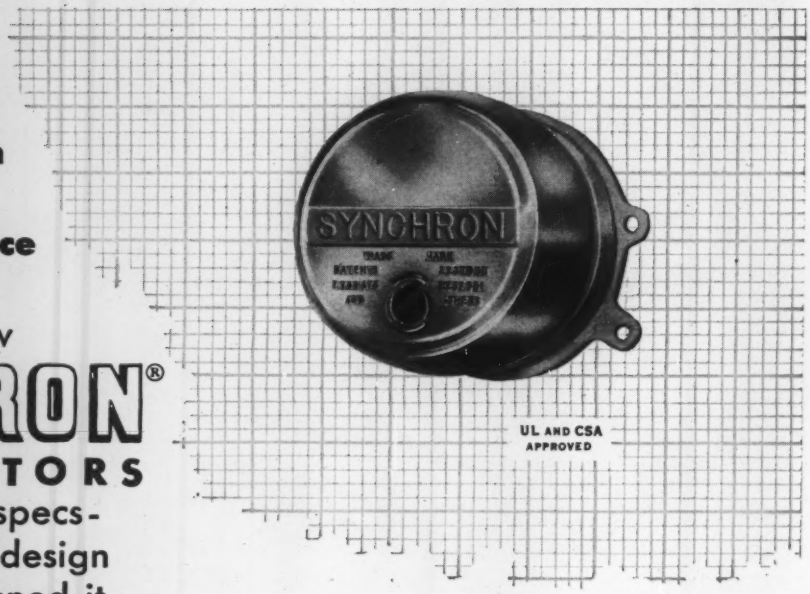
PRATT & WHITNEY

FIRST CHOICE FOR ACCURACY

MACHINE TOOLS • GAGES • CUTTING TOOLS

Circle 462 on page 19

compare...
inch for inch
and
ounce for ounce



find out how

SYNCHRON®

TIMING MOTORS

can match your specs-
best operate your design
the way you designed it

SYNCHRON synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140°F.; start instantly under load; pull up to 20 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

"Workhorse of the industry"

5 Quality Facts — why Synchron Timing Motors are built better to run better

MACHINED TO FINE-WATCH PRECISION — Tolerances as close as .0001 are standard. Strict attention given to quality control in all materials and manufacturing; insure greatest accuracy, dependability; give continuous, trouble-free service.

LIFETIME LUBRICATION — All bearings lubricated in sealed-in Dow-Corning Silicone lubricant, provides lifetime lubrication, stops noise and wear, assures high operating efficiency during motor lifetime from —40° to +140°F.

PRE-TESTED CAPACITY — 51 rigid laboratory tests give performance-proof of top power and efficiency. Tests conducted in temperatures ranging from 40° below zero to 140° above zero F.

STEEL PINIONS AND BRASS GEARS — For quiet operation, sustained accuracy, long life — all steel pinions and rotor shafts, high quality, polished brass engaging gears. Perfect matching of gear teeth stops vibration, assures instant delivery of top power and speed.

FAMOUS HANSEN PATENT — the 100% guarantee of Synchron Quality. Every motor designed, built, and inspected to produce sustained torque power to top rated capacity.

SYNCHRON
5 quality motors . . . by Hansen

STANDARD TIMING MOTOR (8 IN. OZ.) — Compactly built to space saving dimensions, with rotor and coil packed in a sturdy, hand-sized case. Used in timing devices and controls of all types. Guaranteed torque 8 in. oz. at 1 r.p.m.

HI-TORQUE TIMING MOTOR (20 IN. OZ.) — There's big power packed into this versatile timing motor. One year guarantee. Dependable, accurate, trouble-free. Guaranteed torque 20 in. oz. at 1 r.p.m.

SLO-MOTION SYNCHRON (1 R.P.H.) — A new timing motor developed especially for slow motion jobs. Guaranteed torque 20 in. oz. at 1 r.p.h. (1/60 r.p.m.)

CLOCK MOVEMENTS — For standard and office clocks, sign clocks, novelty clocks, and clocks of all kinds up to 26" in diameter under glass. Precision power with a Synchron timing motor.

HANSEN MAGNA-TORC DC MOTOR — Designed for aircraft instruments and radio controls. Armed Forces applications have proved its top performance world-wide under all operating conditions. Easily adapted to commercial uses.

Hansen engineers will gladly provide you with confidential assistance
on special timing motor applications

SYNCHRON TIMING MOTORS IN ALL SPEEDS AVAILABLE FOR PROMPT DELIVERY

SYNCHRON®

SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, MAGNATORC D.C. MOTORS

HANSEN MFG. CO., INC.
OUR 50TH YEAR

Princeton 12, Indiana

FOR FULL INFORMATION CALL OR WRITE TODAY

HANSEN REPRESENTATIVES: The Fromm Co., 5150 W. Madison St., Chicago, Ill. • R. H. Winslow Assoc., 123 E. 37th St., New York, N.Y. • Electric Motor Engineering Inc., Oakland, Calif. • H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton, New York.

viscosity materials, and Agi-Mixers for blending and homogenizing a wide range of materials. Specifications, operation, application and other data are included. 24 pages. Gifford-Wood Co.

Circle 610 on page 19

Steam Traps

Specifications and capacities for Super-Silvertop line of steam traps are contained in condensed bulletin 154. Sizes, pressures, weights and prices also are given, and construction is described. 4 pages. V. D. Anderson Co.

Circle 611 on page 19

Alloy Steel Plate

Processed and heat treated properties of Speed Alloy steel plate are given in bulletin 543. As-furnished tensile strength is 100,000 to 110,000 psi and Brinell hardness is 187-217. Heat treating, welding and application data are presented. 8 pages. W. J. Holliday & Co.

Circle 612 on page 19

Nuclear Welding

"Welding for Nuclear Pumping Applications" outlines welding requirements for nuclear service. Fifteen "do's and don'ts" are prescribed. Photos and drawings illustrate various nuclear pump welding designs and welding set-ups. 11 pages. Borg-Warner Corp., Byron Jackson Div.

Circle 613 on page 19

Jet Aircraft Instruments

Specifications and installation drawings of ten jet aircraft instruments are contained in illustrated bulletin 424. Included are servo amplifier, mach number indicator, airspeed indicator, fuel flow transmitter and others. 4 pages. Norden-Ketay Corp.

Circle 614 on page 19

Ferrite Magnetic Materials

Nature of ferrite magnetic materials, their advantages and limitations, and method of production are covered in illustrated bulletin "Ferramics for General Applications up to 200 Megacycles." Specifications and uses are detailed. 8 pages. General Ceramics Corp.

Circle 615 on page 19

Heat Treating Accessories

Examples of heat treating accessories and fabrications made of alloy steel are content of bulletin. Included are baskets, trays, coils, carburizing boxes, retorts, fan, screens, muffles, box and annealing

HERE'S WHY CARTER CAN OFFER
IMMEDIATE DELIVERY
ANY BORE SIZE • ANY MOUNT • ANY STROKE
CYLINDERS
AIR OR HYDRAULIC

AIR CYLINDERS

750 LB. HYDRAULIC

CLAMP CYLINDERS

1500 LB. HYDRAULIC

AIR VALVES

BUILT-IN VALVE TYPES

SEND FOR COMPLETE CATALOG FILE!
All the details you need for ordering Carter Cylinders and Controls of any kind. Complete with spare parts data, specifications and prices.

● 100% EXPANSION OF FACILITIES
Carter is geared to give service. We have increased our plant capacity to handle orders on an IMMEDIATE DELIVERY basis.

● THE EXCLUSIVE CARTER DESIGN
Carter cylinders are designed for fast production and immediate off-shelf assembly from standard parts.

● THREE SHIFT OPERATION
Carter produces around the clock. Your order for cylinders is in process *in a matter of minutes* after we receive it.

● SPARE PARTS AND SERVICE
Carter maintains complete spare parts and experienced engineers in 40 different locations throughout the United States, Canada, and Mexico.

● PHONE 24 HOURS A DAY
Call in your order any time of the day or night. Carter will take your order and begin processing it right away.

If you need cylinders fast, try us today.

Phone Lansing, Illinois, GRanite 4-3305
or Chicago, BAyport 1-7186

CARTER CONTROLS INCORPORATED
2914 Bernice Road • Lansing, Illinois (Chicago Suburb)
AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

Circle 464 on page 19

DEPENDABLE AIR POWER

CAN IMPROVE THE

Efficiency

OF YOUR PRODUCT

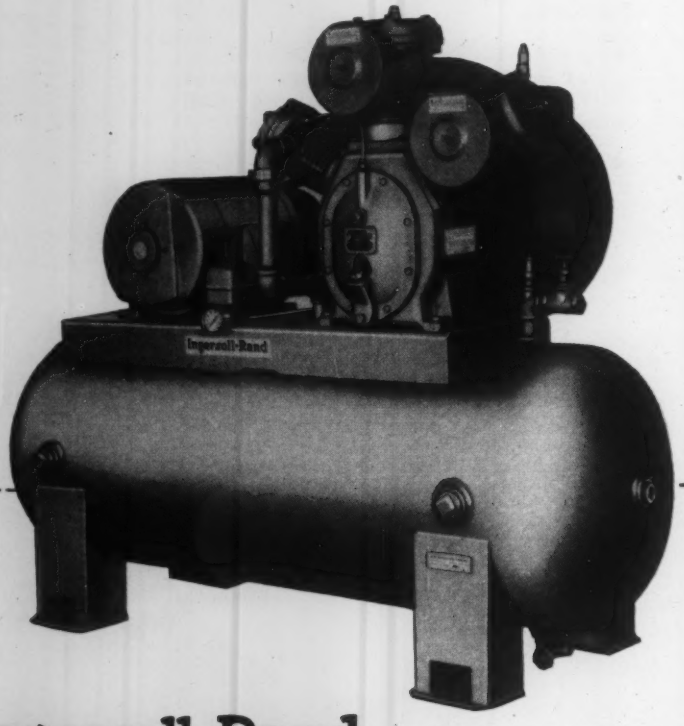
When operation of your equipment hinges on a dependable source of air, get the best compressor. It will add quality and efficiency to your product.

Year after year, since 1878, Ingersoll-Rand air compressors have set new standards of dependable operation through modern design, engineering and production facilities.

Bare, baseplate or receiver mounted air compressors can be supplied to meet your requirements.

Packaged air-cooled compressors—½ through 20 horsepower

Other compressors to 6000 horsepower



Ingersoll-Rand

11 Broadway, New York 4, N.Y.

3-596

Helpful Literature

hood. 4 pages. Aluminum & Architectural Metals Co.

Circle 616 on page 19

Optical Height Gage

Optical height gage which measures heights up to 61 in. with accuracies of ±0.000005-in. per inch of height is subject of illustrated folder. It combines Webber gage blocks and Leitz measuring microscope. 6 pages. Webber Gage Co.

Circle 617 on page 19

Polyethylene Ware

Beakers, aspirator bottles, tubing, pipet-filler, vials and carboys are among polyethylene ware described and illustrated in bulletin FS-268. Material is unbreakable, chemically inert and light in weight. Prices are given. 8 pages. Fisher Scientific Co.

Circle 618 on page 19

Gravity Storage Rack

Rapistan Flow Track, gravity conveyor in its basic form, is subject of illustrated data sheet. Conveyor strip can be combined with other conveyors or used in various combinations of itself. Application ideas are presented. 2 pages. Rapids-Standard Co.

Circle 619 on page 19

Pneumatic Conveyors

Pneumatic conveying of dry, free-flowing materials by Hoffco-veyor systems is described in brochure PN-500. Basic types available, their advantages, installation details and application information are included. 8 pages. U.S. Hoffman Machinery Corp.

Circle 620 on page 19

Carbides

Series of 15 Blue Data Sheets on Carmet carbide grades is keyed with bands of different colors to indicate each grade's function. Each sheet gives typical applications, analysis, physical characteristics and other data. Allegheny Ludlum Steel Corp., Carmet Div.

Circle 621 on page 19

Eyelet Parts

"Deep Drawn Eyelet Parts" is a booklet for users of formed and deep drawn metal parts which covers quality considerations inherent in the manufacture of such items as eyelets, shells, cups and ferrules. Sylvania Electric Products Inc., Parts Div.

Circle 622 on page 19

Another new development using

B.F.Goodrich Chemical *raw materials*

Plastic "springs"! Where can you use a flexing cord?

THIS colorful new cord has no metal spring inside to provide the coiling action.

The "spring" comes from a special jacketing compound using Geon polyvinyl materials which is extruded directly on the insulated conductors. The cord, after forming on a mandrel, "sets" in a coiled position. Thanks to the unique compound based on Geon, the retractile properties are retained through countless flexings.

This new cord, available in bright colors, has obvious benefits as telephone cord . . . and as power or control wiring on machines or equipment where flexing action is required. Or the retractile properties of this compound may suggest entirely different uses.

Geon polyvinyl materials offer excellent electrical properties; resistance to oil, water, and chemicals; superb abrasion and wear properties. For complete information write Dept. GA-4, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of the B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

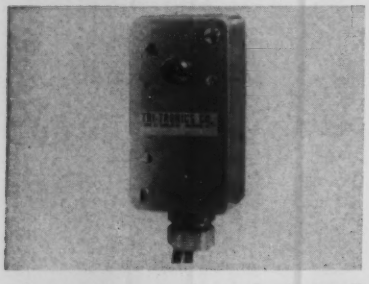
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Photoelectric Relay

miniature unit needs no tubes or transistors

Model P25 miniature photoelectric relay for industrial use provides reliability, small size and minimum maintenance. It plugs into a 120-v line and works without tubes or transistors. High-speed sensitive



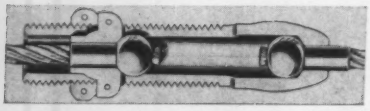
relay, power supply and photocell lens assembly are contained in cast-aluminum case, 4¼ by 2⅛ by 1⅝ in. in size. Unit, available in plug-in and splice-box type, mounts on standard ½-in. conduit hub. Any household lamp can be used as a light source. **Tri-Tronics Co.**, 2607 St. Charles Rd., Bellwood, Ill.

Circle 623 on page 19

Short Turnbuckle

has high tensile and fatigue strength

Cabuckle is one-third as long as standard short AN turnbuckle. It has constant length for any adjustment, can be installed and adjusted with standard tools, eliminates cable twist, and can be lockwired. Assembly consists of slotted sleeve with rolled external threads, forged crosspiece, and hex nut. One cable end is attached to sleeve, the other to crosspiece. Cable tension is adjusted by advancing nut on sleeve, and amount



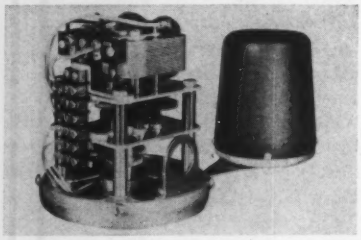
of available adjustment is always visible. Turnbuckles are available in six flexible cable diameters from 1/16 to 7/32-in. Material options include aluminum sleeve and high-strength alloy steel nut and slide or all high-strength alloy steel and all stainless steel assemblies. Tensile and fatigue strength properties exceed requirements of CAA TSC-21. **Voi-Shan Mfg. Co.**, 8463 Higuera Rd., Culver City, Calif.

Circle 624 on page 19

Shaft-Mounted Gearmotor

includes built-in potentiometer

Shaftrol provides remote electrical control with indication of position, speed and valve setting on a calibrated meter. Unit includes built-in potentiometer that provides remote indication and control for valves, adjustable-speed drives, gates, jacks and variable-displacement pumps. Potentiometer also serves in bridge circuits of automatic control systems. Control is



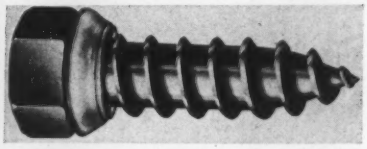
by dial, pushbutton, or from limit switches, controllers or proportioning devices. Unit mounts on shafts from ¼ to 1 in. diam. Full-scale deflection of calibrated meter can be obtained for rotation of driven shaft from 1/6 to 40 or more revolutions. Gearmotors are available for use on single or three-phase circuits with drip-proof, totally enclosed or explosionproof enclosures. **Jordan Co. Inc.**, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Circle 625 on page 19

Fastener-Seals

are waterproof and vibration-damping

Nyltite Staps consist of a self-conforming nylon washer preassembled to a standard self-tapping screw. Washer compresses against head and threads of fastener as screw is turned in and completely seals opening against moisture penetration. Washer deforms at points where stresses are concentrated, distributing load over a



larger area. When load is removed or varied, nylon recovers original shape and maintains seal. Staps are available with any head style. **General American Transportation Corp.**, Parker-Kalon Div., Clifton, N. J.

Circle 626 on page 19

Swing Check Valve

has renewable composition disk

Swing check valve is for service on liquid lines where full unobstructed flow or minimum resistance to flow is desired. Renewable composition disk protects valve seat from

The belt drive p. t. o. stood still . . .

An early-day tractor—International Harvester.

Minneapolis-Moline built this one.

until the splined shaft p. t. o. took over . . .

A late model Allis-Chalmers.

. . . providing flexible power transmission to all implements equipped with adaptable

BLOOD BROTHERS Jointed Drive Lines

History was made when engineers first replaced the "pulley p.t.o." with the universal-jointed shaft. For this concept of flexible power transmission was the key to Progress. Implements that had, until then, remained stationary in the fields now moved forward. And the whole implement industry moved forward too—building innumerable new, better machines driven through universally adaptable, flexible drive line assemblies. Working with the manufacturers, Blood Brothers has kept pace—by building stronger, better drive lines for every farm implement requirement. If *you* build implements, consult Blood Brothers for helpful cooperation.

FOR FARM IMPLEMENTS, MORE BLOOD BROTHERS UNIVERSAL JOINTS ARE USED THAN ALL OTHER MAKES COMBINED

TAKES POWER AROUND CORNERS

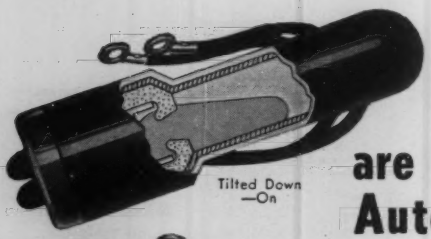
BLOOD BROTHERS MACHINE DIVISION

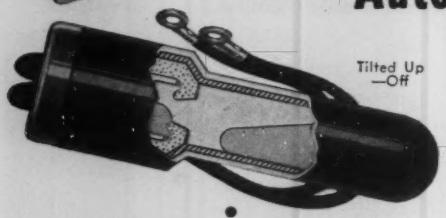
ROCKWELL SPRING AND AXLE COMPANY

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Circle 467 on page 19





DURAKOOL Tilt Switches are the Life of your Automatic Controls

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

MILLIONS OF CYCLES WITHOUT FALTERING

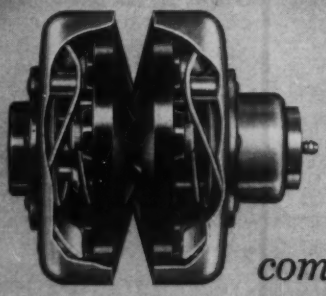
See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Durakool ALL-STEEL MERCURY *Switches*

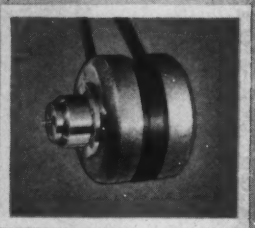
Circle 468 on page 19

DESIGN-WISE...



this simple pulley solves complicated problems

Compactness of *HI-LO* automatic variable speed pulleys simplifies basic machine design in a vast range of applications. The exclusive design of cam followers on cams provides simple, positive pitch diameter setting control. Springs in HI-LO pulleys are not driving members as in most spring-loaded pulleys, but serve primarily to keep the pulley faces in contact with the belt. Belt wear is reduced to a minimum because the belt is never under any more tension than is required by the load. Free technical manuals with diagrams, descriptions of applications and other power transmission data are available from:

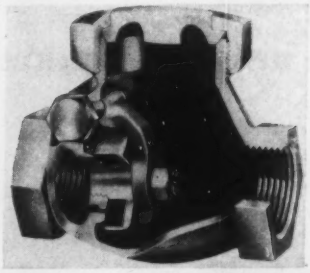


Equipment Engineering Company
2855 Columbus Ave., Minneapolis, Minnesota

Circle 469 on page 19

New Parts

damage due to solid particles in steam and from shocks of pulsating pressures. Disk can be replaced without removing valve body from line. Bronze valve is



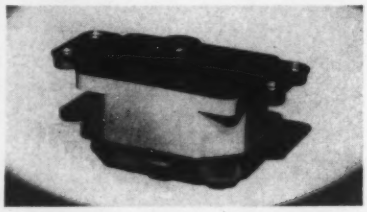
rated at 150 psi steam working pressure, 300 psi cold water, oil or gas pressure, nonshock. It is available in sizes from ½ to 2 in. **Fairbanks Co.**, 393 Lafayette St., New York 3, N. Y.

Circle 627 on page 19

Circuit Breaker

is shock and vibration-resistant

Klixon C7855 weatherproof, precision, heavy-duty circuit breaker is for use in aircraft, trucks, transformers, ground-powered generating equipment and other applications requiring high shock and vibration resistance. Ratings range from 105 to 200 amp, and each



unit is individually calibrated. Automatic and manual-reset types are available. **Metals & Controls Corp.**, Spencer Thermostat Div., Attleboro, Mass.

Circle 628 on page 19

Ball Bearings

have Teflon seals

Bearings with Teflon contact seals are for applications requiring sustained high-speed performance. Full metal shield which keeps dirt out and locks lube in is permanently attached by crimping to out-

A Man Nobody Wants

This man's motto is "Don't rock the boat!" Now that he has reached his present high post in the Company, his life is dedicated to proving that once you get a good thing, you don't have to change. In fact, if things get too new, you can always search the past for something really safe to use.

He, naturally, has no interest in the new things coming out of Rogers.

Rogers is not looking for him, either. Rogers serves engineers – those men who sail the seven seas in search of an eighth. And they, in turn, find Rogers an interesting port of call – a cove of research and development brains eager to meet the challenge of their ideas with new materials.

Our business is to create – if we don't already have them – the materials that engineers are seeking to convert today's dreams into actual products. Please write for samples of recent developments.

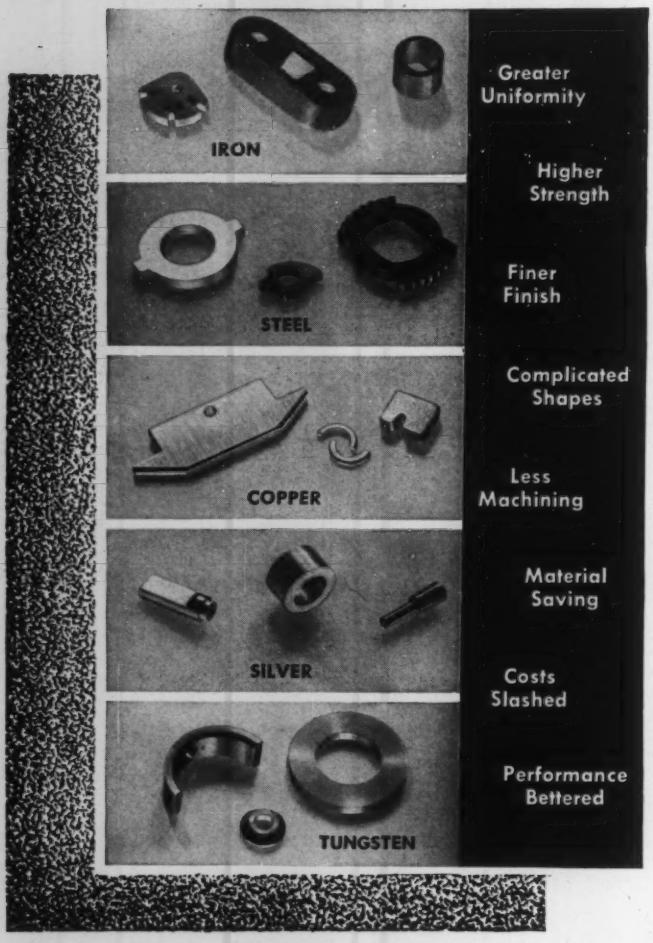
ROGERS
CORPORATION
ROGERS, CONNECTICUT

DUROIDS—for Gaskets, Filters, Electronic Devices, Thermal Insulation, etc. ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc. PLASTICS—Special Purpose Molding Compounds and Laminates RUBBER—for Floats, Grommets, Gaskets, Bearing Seals, etc.
FABRICATING—Including Converting, Combining, Coating, Embossing, and Molding DEVELOPMENT—Research and Engineering of Unique Materials, Parts and Products

Perhaps

SUPERIOR Powdered Metal Parts

CAN CUT Your COSTS IN HALF, TOO!



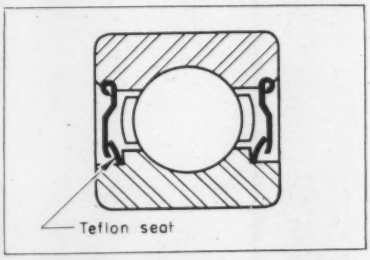
CUT COSTS, NOT PARTS

Superior Powder Metallurgy often makes possible tremendous savings. Parts virtually impossible with other materials are easy with this method. Note the other advantages listed above and then... tell us what your job or problem is, preferably via blue print or drawing. Perhaps we can cut *your* costs in half, too.

SUPERIOR CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO

SCP
SUPERIOR CARBON BRUSHES
"Since 1919"

New Parts



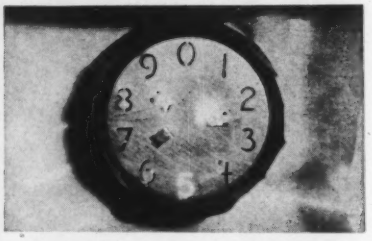
er raceway. Teflon seal maintains positive contact with shield and completes barrier. Bearings are available in double and single-contact seal, and single and double seal with snap-ring types, in light or medium series. **Hoover Ball & Bearing Co.**, 326 E. Hoover Ave., Ann Arbor, Mich.

Circle 629 on page 19

Read-Out Device

is ten-position unit with common anode

HB-105 Pixie is a gas-filled, cold-cathode, ten-position read-out device, having a common anode. It features ten glow positions, 36 deg apart, visible through ten numerical perforations in common anode. Numerical indication is determined by position of spot as it appears under an internal bezel in tube. Unit is useful in applications where multiple readings are desired simultaneously or where



spot-position is advantageous for read-out, such as in compass or clock-type readings. **Burroughs Corp.**, Electronic Tube Div., Plainfield, N.J.

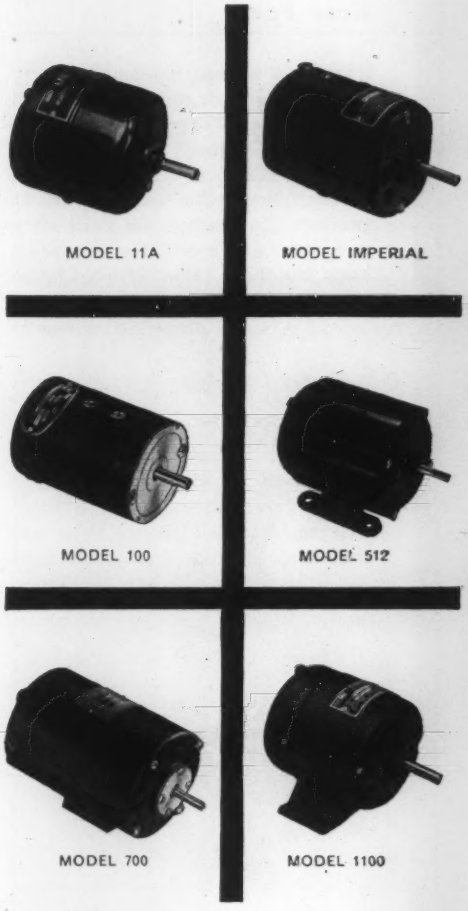
Circle 630 on page 19

Powdered Chromate Coating

for nonferrous metals

Kenvert No. 8 is a powdered chromate coating which produces iridescent films on zinc, cadmium, copper, brass and zinc die castings. It can be adjusted to give varying

Circle 471 on page 19



MORE THAN *50,000 DIFFERENT SPECS* HAVE BEEN FILLED BY THESE 6 HOWARD UNIVERSAL AND D.C. FRACTIONAL H.P. MOTORS

These 6 Howard motors account for over 50,000 specifications, both military and commercial. One reason for this wide use is Howard's ability to produce variations *exactly* suited to specific needs.

Howard motors have such field-proven engineering features as automatic slot cell insertion, which practically eliminates "grounds;" Zanderoll processed double dipped and double baked armatures providing deep, uniform varnish penetration for high bond strength and rock-hard coils minimizing "shorts and opens;" improved brushholder construction for accurate alignment and longer life; 2-stage, 3-plane dynamic balancing; and automatic winding for tough compact coils, giving uniform performance.

If you are currently using universal and D.C. motors from 1/200th to ½ H.P., check with Howard today.

GEAR REDUCTION UNITS		
Model	Ratio	
	min.	max.
11A	3:1	2700:1
Imperial	3:1	2700:1
100	3:1	2700:1
512	3:1	2700:1
700	21.5:1	2600:1
1100	3:1	2700:1

ELECTRICAL SPECIFICATIONS

MODEL 11A		MODEL 100		MODEL 512	
SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR
15M	3.5-10M			15M	2-9M
5-10M	3-8M	5-10M	1.8-6M	5-10M	1.8-6M
1/75 No Fan	1/75 No Fan	1/50	1/50	1/10	1/12
1/20	1/20	1/13	1/13	1/5	1/6
.4	.4	.35	1.6 at 24V	1.5	1.5
.75	.75	1.0	5 at 24V	3.0	3.0
30	30	35	35	50	45
35	35	45	45	60	55
12-115	6-120	12-120	6-32	24-230	12-230
CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.

Maximum H.P. ratings are shown. Variations are available for less power to meet application requirements.

Other Howard motors: UNIVERSAL & D.C. 1/200 to 1/2 h.p. • SHADED POLE 1/2000 to 1/8 h.p. INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

HOWARD

HOWARD INDUSTRIES, INC., 1735 STATE ST., RACINE, WIS., TELETYPE: RAC 344

Sales Offices 208 S. La Salle St., Chicago 4 / 942 S. La Brea Ave., Los Angeles 36 / Room 4822, Empire State Bldg., New York 1 / 300 Broadway, Camden, New Jersey

Buy Defense Bonds

DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS

NO SLURRY SETTLING

Imagine . . . a slurry pump which permits the proportion of slurries in the mix tank to remain constant . . . with pumping rates variable from max mum to ⅓ of maximum. Manzel *guarantees* such performance with its new SP-90 Slurry Pump. Field engineers are ready to consult with you.

WRITE FOR COMPLETE CATALOG

Manzel

CHEMICAL FEEDERS • SLURRY PUMPS

976 BABCOCK STREET • BUFFALO 10, NEW YORK

New Parts

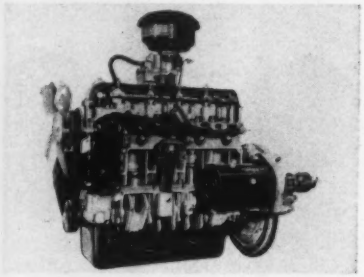
iridescent bronze shades by varying pH, concentration, and time of immersion. Corrosion protection meets all government specifications. Bath can be operated through controlled temperature to produce films which are hard when wet, and which will not bruise in bulk handling. **Conversion Chemical Corp.,** Rockville, Conn.

Circle 631 on page 19

Industrial Engine

produces up to 45 hp at 5500 rpm

Fageol 44 lightweight industrial engine is used for farm and hoisting machinery, lift trucks, tow tractors, construction equipment, fire pumpers and portable generators. A four-cycle, four-cylinder, water-cooled power plant, it has 9:1 compression ratio and overhead valves operated by gear-driven overhead camshaft. Unit produces up to 45 hp at 5500 rpm. **Twin Coach Co.,** Fageol Products Div., 850 W. Main St., Kent, O.



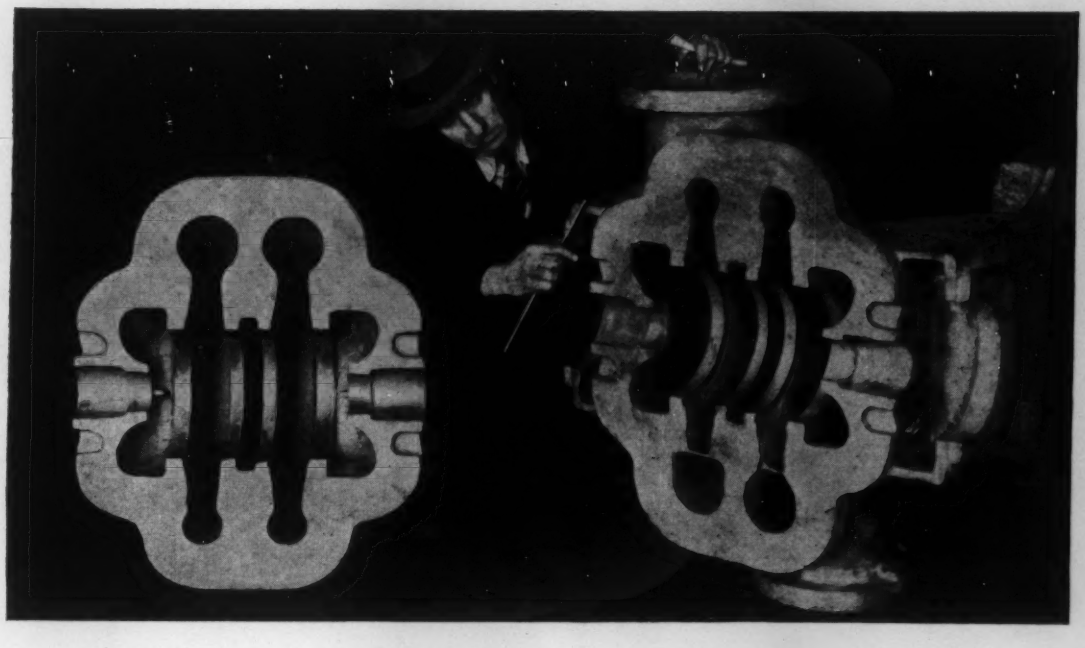
Circle 632 on page 19

Voltage Regulator

maintains output voltage of 60-cycle alternators

Voltage regulator is a single-stage magnetic-amplifier unit utilizing selenium rectifiers and wire-wound resistors. It is completely static, and has no moving parts. Unit maintains output voltage of 60-cycle alternators constant. It works into a 20 to 100-ohm exciter field resistance without adjustment, and supplies exciter field current within 0.15 to 1.35 amp. Unit connects directly into any 208 to 240-v alternator without need of potential transformer. When used with a 500-va potential trans-

Circle 473 on page 19



There's NO problem in Stainless Castings that we can't answer for you—

Write for this book on A-L STAINLESS STEEL CASTINGS

28 pages of valuable and complete data on stainless castings: analyses, properties, technical data on handling and heat treatment, typical applications, how to order, etc.

ADDRESS DEPT. MD-91

Odd shapes or intricate sections are certainly no problem—look at some of our stainless steel casting products illustrated above. We could show you hundreds more. And size is no consideration, either—we're equipped to handle any stainless castings—from a few ounces to thousands of pounds.

The really important point for you to consider is not the matter of shape or size, but of *experience*. The A-L Buffalo Foundry is a group of specialists in high-alloy steel castings *exclusively* . . . . pioneers in both the static and vertical-centrifugal methods of casting stainless steels.

For your assurance, there's a long record of years of successfully answering difficult service conditions with sound, clean-grained Allegheny stainless castings—free from defects, easy to machine and dependable in supply.

● Let us quote on *your* stainless casting requirements . . . any size, any shape. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

WSW 6833

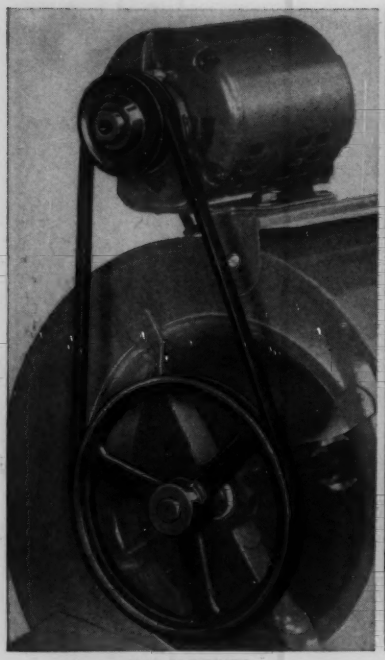
Make it BETTER—and LONGER LASTING—with

Allegheny Stainless

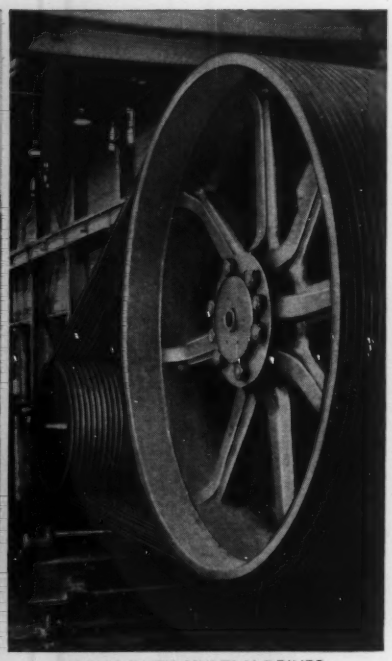
AL ALLEGHENY LUDLUM

Warehouse stocks carried by all Ryerson steel plants

Circle 474 on page 19



FHP V-DRIVES

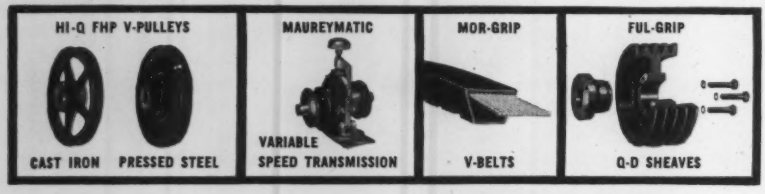


HEAVY DUTY MULTI V-DRIVES

Since 1917...

American industry has approved maurey quality

40 years since 1917 have taught us at Maurey that American industry appreciates quality. Today's complete Maurey V-Drive line reflects that lesson. The Maurey Hi-Q V-Pulley ranks No.1 in the FHP V-Pulley field on true-running, belt-saving performance and wide industrial use. In the field of heavy duty drives, Maurey Ful-Grip Q-D Sheaves and standard Multi-V sheaves are recognized quality leaders. Every Maurey Mor-Grip V-Belt, and V-Drive accessory is engineered and quality-built to deliver the finest, most dependable V-drive performance your dollar can buy. The free literature listed below will help you to better V-drive performance. Write for it.



For V-Drive Users, Designers
- V-Drive Engineering Manual
- FHP V-Drive Catalog No. F-10
- V-Belt Catalog No. V-55
- Multiple V-Drive Catalog No. MVD-56
- Maureymatic Variable Speed Transmission Catalog No. MM-56

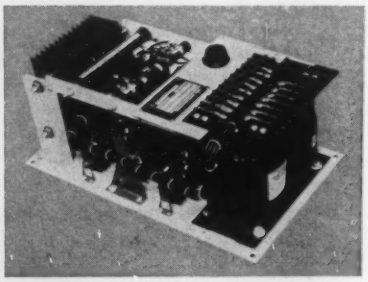
Write for free copies.

maurey

MANUFACTURING CORPORATION, 2903-27 S. WABASH AVE., CHICAGO 16, ILL.

Circle 475 on page 19

New Parts



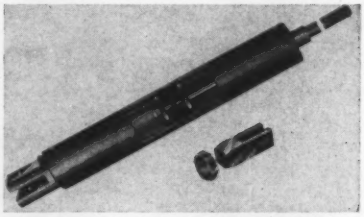
former, it operates with alternators of any output voltage. **Vickers Inc.**, Vickers Electric Div., 1815 Locust St., St. Louis 3, Mo.

Circle 633 on page 19

Cylinders

in seven bore sizes from ⅞ to 4 in.

Types AN and BN cylinders have fork-type rear head for mounting, stainless-steel rods, Nylined bearings, high-tensile aluminum heads, corrosion-resistant honed-brass or steel tubing, and fixed or adjustable cushions for either or both ends. Bore sizes range from ⅞ to 4 in. Type BN cylinders use cups for the piston-head seals; Type AN use O-ring packing. All



cylinders are available in double-acting or single-acting spring return styles. **A. K. Allen Co., 57** Meserole Ave., Brooklyn 22, N.Y.

Circle 634 on page 19

Pipe Fitting

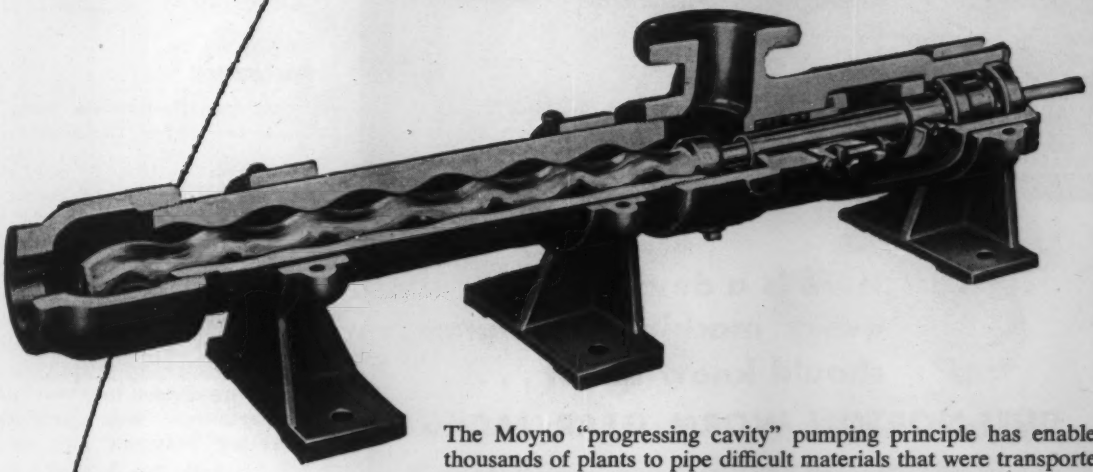
has cropped edges

Tru-Seal self-sealing pipe fitting has chromated cadmium surface treatment wihch provides golden color and good resistance to corrosion. Cropped edges make fitting compact and prevent overtightening. Fitting is available in pipe thread sizes from ⅛ through 2½ in. Fitting seals at pipe thread connections with a white, threaded insert of Teflon. Unit

from abrasive slurries to delicate foods . . .

MOYNO® PUMPS

CUT HANDLING COSTS



The Moyno "progressing cavity" pumping principle has enabled thousands of plants to pipe difficult materials that were transported by hand and other expensive means. Moyno is the only pump that can handle many abrasives, pastes, slurries, chemicals, foods, suspended solids, etc., without foaming, aerating, crushing or excessive pump wear.

As shown above, Moyno Pumps have a screw-like rotor that revolves in a double threaded stator creating progressing cavities which smoothly move material through the pump. They will pump anything that will move through a pipe . . . even plaster and non-pourable pastes!

Moyno Pumps are available in capacities up to 500 gpm and pressures up to 1000 psi.

Examine your processing methods. No doubt there are several places where Moyno Pumps can drastically cut costs. Ask us, we'll give you a frank answer. Send us an outline of your problem today! Write for Bulletin 30-MD

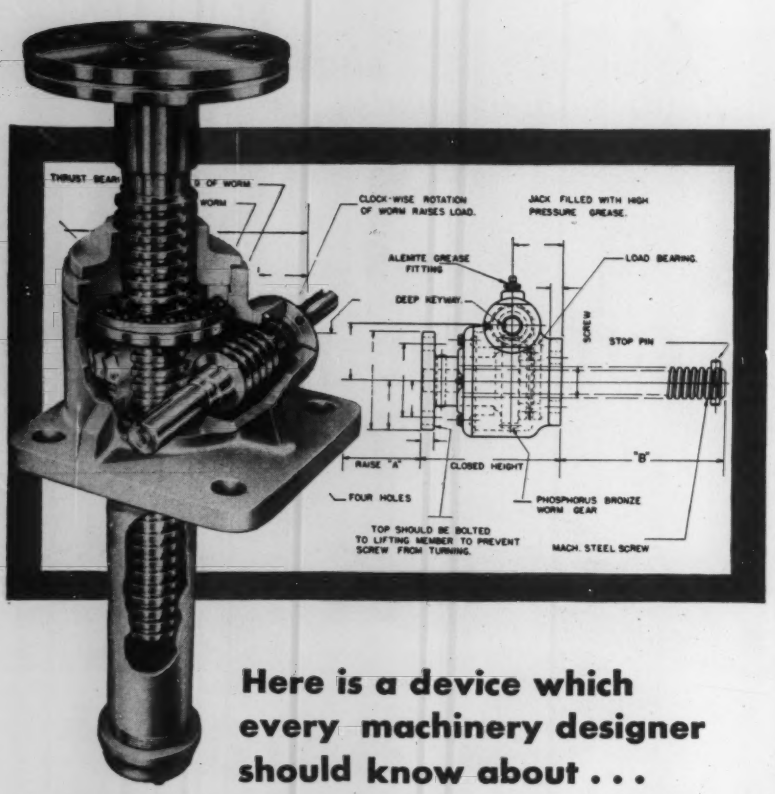
R&M®

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

Motors | Fans | Hoists | Moyno® Pumps | Propellair® (Industrial) Fans

Circle 476 on page 19



Here is a device which every machinery designer should know about . . .

DUFF-NORTON WORM GEAR JACKS

Duff-Norton worm gear jacks provide a purely mechanical means for accurate positioning of loads weighing as much as several hundred tons and maintaining them indefinitely without creep. They will operate in any position, and functioning as components of machinery and equipment they can raise and lower loads, apply pressure or resist impact. Jack capacities range from five to 50 tons. When two or more jacks are connected by means of shafting and mitre gear boxes they lift in unison, even when the load is unevenly distributed. They are available with standard raises up to 25 inches, and will provide exactly the same raise for years without adjustment. Worm gear jacks are suitable for operation at ambient temperatures up to 200°F.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, arbor presses, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting bulletin AD-34-V, which includes drawings and full specifications.

DUFF-NORTON **Duff-Norton Jacks**

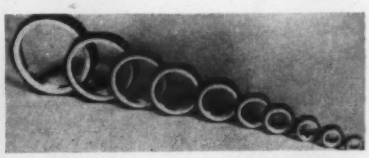
DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION: Danville, Illinois

Ratchet Jacks, Screw Jacks, Hydraulic Jacks, Special Worm Gear Jacks, Ratchet Hoists, Electric Hoists, Load Binders, Spur Gear Hoists

New Parts



holds its seal under ultimate pressures of 10,000 psi and temperatures from − 200 to 500 F. **Flick-Reedy Corp.**, Tru-Seal Div., 2040 N. Hawthorne Ave., Melrose Park, Ill.

Circle 635 on page 19

Pushbutton

combines pushbutton and selector-switch functions

Roto-Push combines pushbutton and selector-switch functions in a single unit. One of two or three circuits is selected by turning switch collar, then actuated by pushing button. Unit is available in either transformer or resistor types, and is oiltight, utilizing neoprene-diaphragm seal. Contact blocks are divided into two isolated compartments with individually operating plungers and circuits.

Circuits can be both normally open, both normally closed, or one normally open and one normally closed. **Cutler-Hammer Inc.**, 328 N. 12th St., Milwaukee, Wis.

Circle 636 on page 19

Magnetic Counters

in miniature size

Three and four-digit miniature magnetic counters are available in additive or subtractive types with manual reset wheels. They record pulses to 1200 counts per minute. Actuated electromagnetically, counters can be connected in vacuum-tube plate circuits or oper-

Circle 477 on page 19

Prolong machinery life and save money—

with FALK Steelflex Couplings

Ever since the first Falk Steelflex Coupling was designed and built, we have firmly held to these beliefs:

1. A coupling, to give fullest value, must do more than merely *connect* driving and driven machinery—it must *protect* the machinery and prolong its life.

2. A coupling, to be truly flexible, must overcome the effects of shock and vibration, as well as shaft misalignment.

Proof of the soundness of those beliefs is furnished by the record. More than one million Falk Steelflex Couplings have been used on every conceivable type of industrial application . . . giving trouble-free service, providing maximum protection to connected machinery.

* A single basic type—the famous Type F—fills 90% of all industrial application needs. It is versatile, efficient and economical. And—it is always available from factory, field or distributor stocks, in a wide range of sizes.

Write to Department 247 for engineering bulletin, including selection and dimension tables.

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF:

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry

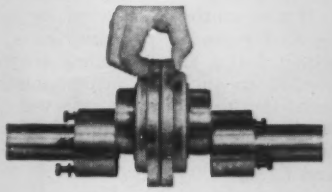
Circle 478 on page 19

The New Type F Spacer Coupling

Here is a Steelflex coupling specially designed to permit fast, easy installation and removal in horizontal and vertical applications where it is impracticable to move the connected units—or where a space-gap (up to 12 in.) is necessary.

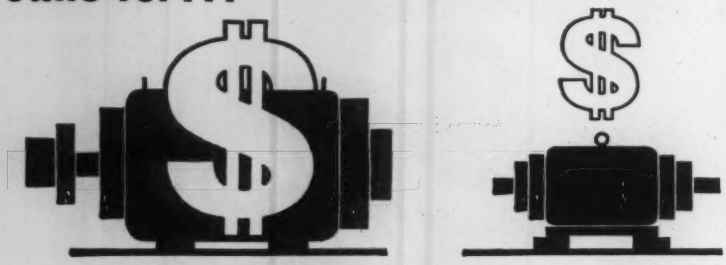
Like all Steelflex couplings, the Type F Spacer gives long, trouble-free service and maximum 3-way protection for connected machinery: it provides torsional resilience to reduce shock and vibration; it accommodates parallel or angular shaft misalignment; it allows free (or limited) end float.

An outstanding feature of the Steelflex Spacer is that it can be installed or removed in one piece (see photo below); no dismantling or servicing of the coupling is required. Pump assemblies can be disconnected and removed without disassembling the coupling, without exposing working parts.



The Steelflex Spacer coupling is prelubricated at the Factory and can be installed, or removed and reinstalled, without disturbing the lubricant—a highly desirable feature.

When electrically driven equipment calls for...



a special, costlier motor to start things

but only a low-cost motor to run them

Why not try this...

A National Torque Converter to give high starting torque | with your cost-saving motor to keep things moving

National Torque Converters give you "big motor" torque from small motor investment

Like a car in heavy traffic, the work-cycle of a lot of heavy, electrically-driven equipment is stop-and-go, stop-and-go.

If the motor is selected to take care of *running* requirements, it won't have the starting torque needed to pick up heavy loading fast. If the motor is selected for *starting* requirements, it is likely to cost considerably more—both to buy and to run.

The best answer is to install the more economical motor—and let it drive through a National Torque Converter. The converter will multiply the motor's torque for picking up the loads . . . ease the shocks and stresses of operation . . . bring economy in first cost and day-to-day service. National Torque Converters are available in a range of capacities from 100 to 1000 HP. For detailed technical information, just write:

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

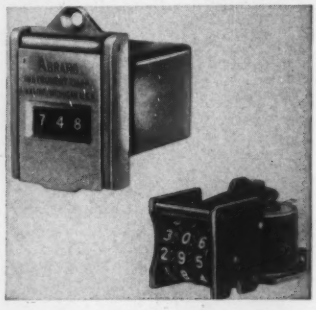
Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

Circle 479 on page 19

New Parts

ated by any contacting device. Variety of mounting methods is possible and units are available with or without panel-mount cases. Counters withstand environmental requirements and are furnished for



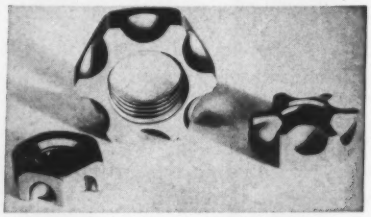
all common voltages from 6 to 110 v dc. Three-figure unit without cases measures about ⅞ x ⅞ x 2 in. **Abrams Instrument Corp.**, 606 E. Shiawassee St., Lansing, Mich.

Circle 637 on page 19

Locknuts

steel units are lightweight

Lightweight steel locknuts, intended for aircraft instruments and electronic components, are up to 49 per cent lighter with same holding strength as conventional locknuts. The cold-forged locknuts have full wrenching area and can be used indefinitely as jam or lock-



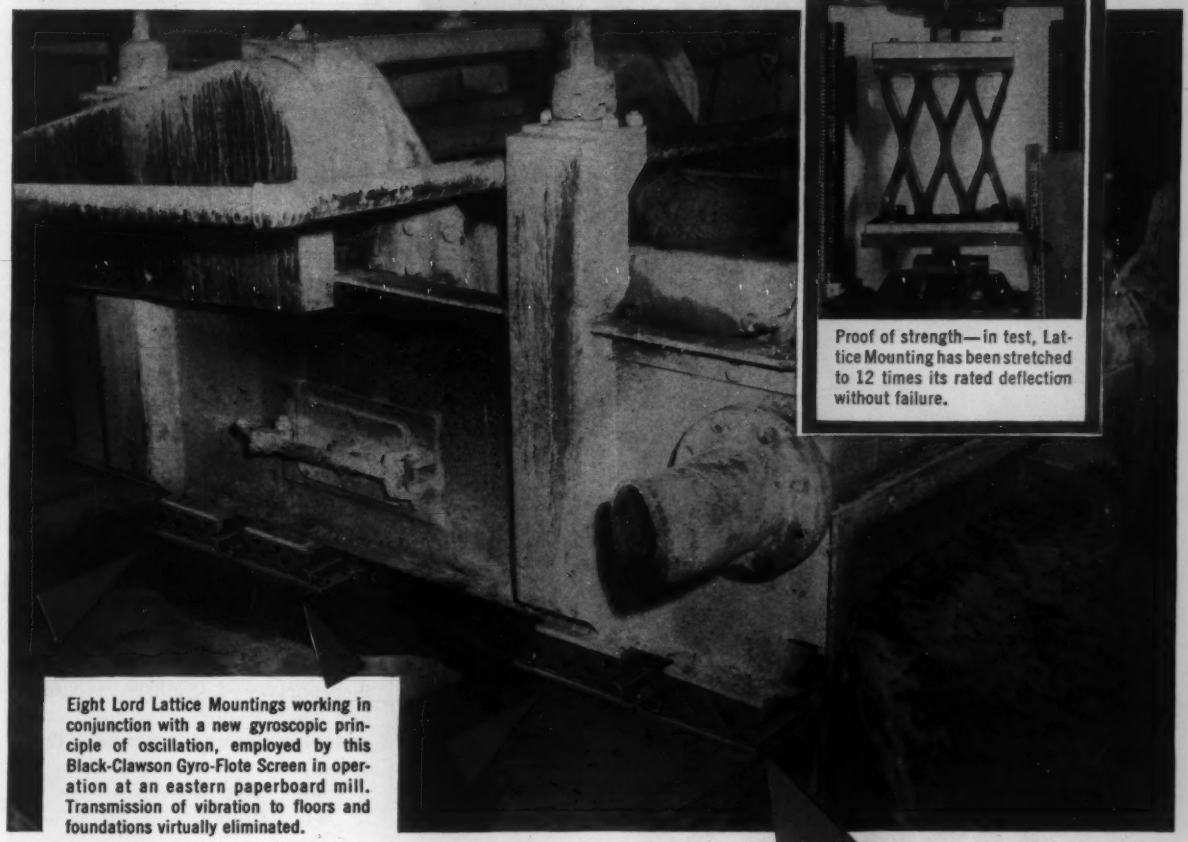
nuts. They are available in 10-32 and ¼-28 sizes, and are for applications to 550 F. **Standard Pressed Steel Co.**, Stewart Ave., Jenkintown, Pa.

Circle 638 on page 19

Motor-Generator

is size 18 unit

Size-18 motor-generator has maximum rms null voltages of 13 mv total and 8 mv fundamental. Motor and generator are combined in assembly having a single shaft.



Proof of strength—in test, Lattice Mounting has been stretched to 12 times its rated deflection without failure.

Eight Lord Lattice Mountings working in conjunction with a new gyroscopic principle of oscillation, employed by this Black-Clawson Gyro-Flote Screen in operation at an eastern paperboard mill. Transmission of vibration to floors and foundations virtually eliminated.

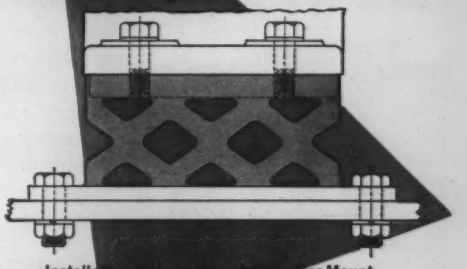
how to isolate heavy-duty machinery vibrations

LORD LATTICE MOUNTINGS PROVIDE FLEXIBLE SUPPORT—DAMPEN LOW FREQUENCY, HIGH AMPLITUDE VIBRATIONS

Efficiency-destroying machine noise and vibration can be effectively reduced by using LORD Lattice Mountings. Placed under vibrating machinery, they absorb intermittent or continuous pounding, protect performance. Installation is a simple bolting operation using tapped holes in the upper plate and through holes in the lower plate of the unit.

The patented lattice design of the flexing element, perfected by LORD research and engineering, provides soft spring rate characteristics in all directions with good horizontal stability. This element is permanently bonded to steel plates, forming a simple, one-piece unit that *never* requires maintenance.

LORD Lattice Mountings are available in load ratings from 250 to 3,000 pounds per mounting. A complete description is contained in Bulletin No. 701. For your copy, or other information, contact your nearest LORD Field Engineer or write the Home Office, Erie, Pennsylvania.



Installation diagram showing Lattice Mountings provides a flexible but rugged base for heavy equipment. Installation of long-lasting Mountings is easy and quick.

Lord Lattice Mountings are covered by U. S. Patent Nos. 2322193 and RE22280.

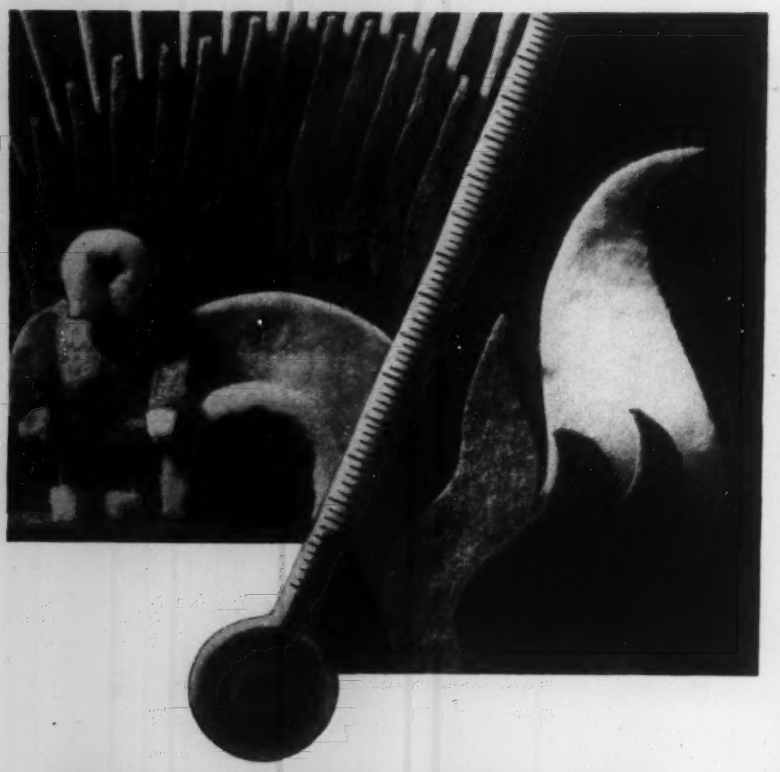
LORD MANUFACTURING COMPANY • ERIE, PA.

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924

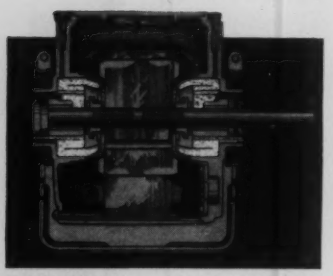
ATLANTA, GEORGIA - CEdar 7-1123
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - Michigan 2-6010
CLEVELAND, OHIO - SHadyside 9-3175
DALLAS, TEXAS - Riverside 1-3392
DAYTON, OHIO - Michigan 8871
DETROIT, MICH. - TRinity 4-2060
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - LOcust 4-0147
"In Canada—Railway & Power Engineering Corporation Limited"

Circle 480 on page 19



Felt Stands the Gaff

...FROM −80°F TO 250°F



FELT IN USE . . . Small motors use felt washers, rectangles, odd shapes and wicks in many places to increase reliability, like on this Redmond Micromotor shown here. Felt wicking and pourous bronze bushings provide positive lubrication for long, heavy-duty operation in any position. Felt seals also keep dirt and dust out of vital areas.

Felt by Felters has what it takes when operating conditions are extreme.

Stands over 30 days at 250°F of dry heat without materially weakening its structure. Same at −60°F as at normal 74°F and at −80°F its properties are only slightly different. Even when exposed to greater extremes, felt will always resume its natural feel.

Send for Design Book

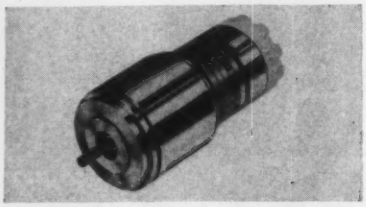
Complete technical data has been prepared for your use in selecting and specifying the *right* felt for the job your product has to do. Send for it today. The Felters Company, 242 South St., Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products — Representatives in All Principal Cities

New Parts



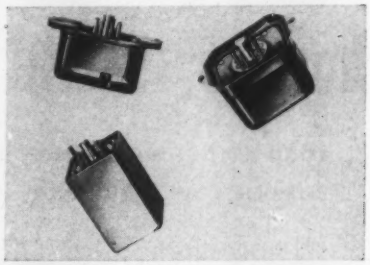
Motor has diameter of 1.750 in. and is designed for operation on 400 cycles with stall torque of 2.35 oz-in. Voltages are 26 or 115 v on fixed phase, and 26, 115 or 230 v on control phase. Generator is 1.5 in. in diameter and is for operation on 400 cycles. **G-M Laboratories Inc.,** 4300 N. Knox Ave., Chicago 41, Ill.

Circle 639 on page 19

Polar Relay

has built-in preamplifier

Myza transistorized dc polar relay incorporates a built-in preamplifier, thus requiring reduced input power to operate contacts. Three types of contact operation are available. Applications include use in Wheatstone-Bridge circuits, in



remote positioning and synchronizing, and in speed control. **Barber-Colman Co.,** Electrical Components Div., 1300 Rock St., Rockford, Ill.

Circle 640 on page 19

Silicone Rubber

for use in temperatures from −130 to 500 F

Tough, strong heat-stable silicone rubber, designated Silastic 916, combines thermal stability and high dielectric properties of silicone rubber with mechanical strength and abrasion resistance close to that of organic rubbers. Rubber is nontoxic, serviceable at low temperatures, and eas-

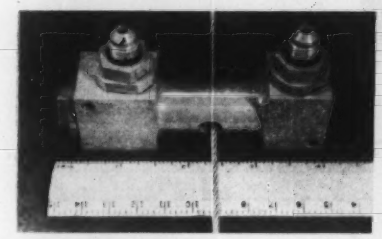
ily processed. It can be milled and compounded after long shelf-aging. Suitable for molding, extruding or calendering, it can be hot-air vulcanized. Tensile strength is about 1500 psi, tear strength approximately 200 ppi. Durometer is from 50 to 60 on Shore A scale. Useful temperature range extends from −130 to over 500 F. **Dow Corning Corp.**, Midland, Mich.

Circle 641 on page 19

Cable Cutter

is ballistically operated

Triggered by low gas pressure, a ballistically-operated cable cutter has self-contained cartridges. In-



dependently fired, each cartridge produces sufficient force to sever a ⅛-in. diam steel cable. Unit is 4 in. long, 1 in. wide, 2¼ in. high, and weighs 0.45-lb. Originally designed for use in pilot ejection seats, device is applicable to any system requiring instantaneous, reliable cutting of cables, wires, tubes or rods. Other models operate from mechanical or electrical signals, rather than pressure input. **Stanley Aviation Corp.**, Denver, Colo.

Circle 642 on page 19

Industrial Coolant Pump

driven by 24-v dc electric motor

Model RG16070 pump is designed to pump water or a mixture of water, butyl alcohol and ethylene glycol in heat exchangers on large equipment. It is also used as a transfer pump for water or other fluid mixtures. Unit has minimum rating of 400 gph with 14 to 16 psi absolute inlet pressure and 15 psi gage discharge pressure. Unit also incorporates a relief valve set to bypass full flow at 50 psi gage. Motor is ¼ hp, 1750 rpm, 24-v dc

"headache"

jobs in Investment Casting?
Come to ARWOOD!

Intricate shapes . . . unusual contours . . . fine detail . . . metals and alloys difficult to machine . . . rigid quality control specifications . . . unyielding performance requirements—These are production "headaches" ARWOOD can cure, without difficulty.

Expert research, design and development staffs, multi-plant tooling, casting and finish-machining, Government-approved, in-plant heat treating and inspection, 54 field engineers in 20 major industrial centers . . . ARWOOD's prescription for the cure. Do YOU have this kind of headache? Write TODAY for literature on our "prescription"!

ARWOOD PRECISION CASTING CORP.
315 West 44th Street • New York 36, New York
"Pioneers in Investment Casting"
Plants: Brooklyn, N. Y., Groton, Conn., Tilton, N. H., Los Angeles, Calif.

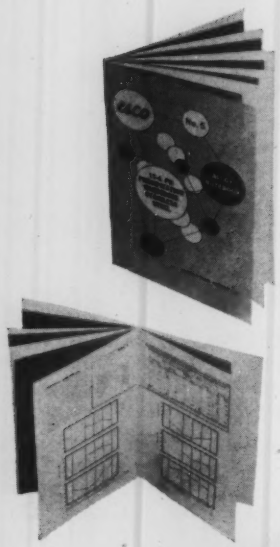
Circle 482 on page 19

JUST OFF THE PRESS

ESCO ALLOY NOTEBOOK No. 5

PRECIPITATION HARDENING ALLOY 17-4 PH *

* Armco Licensee



Here is the first information published on the mechanical properties after various heat treatments, of cast alloy 17-4 PH. This true heat and corrosion resistant stainless steel can be machined, in its relatively soft as-cast condition, and hardened to 400 BHN at low temperatures. 17-4 PH also has the ability, through heat treating, of being adaptable to a wide range of applications requiring high strength, ductility and impact resistance.

This report of a continuing study contains pictures, tables and graphs, showing such things as the microstructure before and after annealing and the comparative mechanical properties of 17-4 PH.

Industry as diversified as aircraft parts, food processing equipment and chemical pump manufacturers are among the enthusiastic users of Alloy 17-4 PH.

Write for your free copy today.

ESCO®

ELECTRIC STEEL FOUNDRY COMPANY

2183 N. W. 25TH AVE. • PORTLAND 10, OREGON

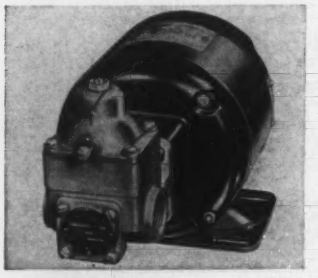
MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.

Offices in Most Principal Cities

ESCO INTERNATIONAL, NEW YORK, N. Y.

IN CANADA ESCO LIMITED

Circle 483 on page 19



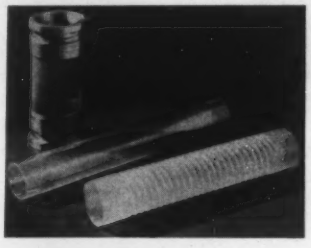
continuous-duty type. **Lear Inc.**, Lear-Romec Div., Elyria, O.

Circle 643 on page 19

Kel-F Tubing

in diameters from 2 to 6 in.

Large-diameter, thin-wall Kel-F tubing has no seams or heat sealing, and is completely homogeneous and transparent. Diameters are from 2 to 6 in. and lengths to 12 in. Wall thickness of 0.060 to 0.80-in. provides excellent chemical resistance, high strength and high pressure resistance. Tubing is suitable for fuel gages, pipe sections, linings, O-rings and seals of large



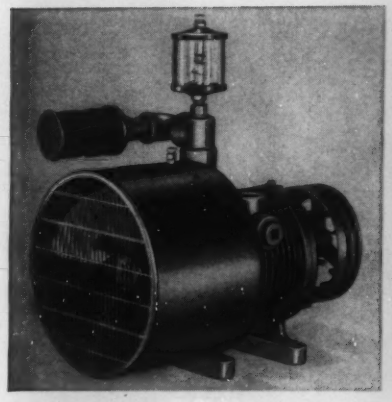
diameter. It can be bent to provide flexible couplings and joints. **Combs Engineering & Mfg. Co.**, 428 S. Cherry St., Wallingford, Conn.

Circle 644 on page 19

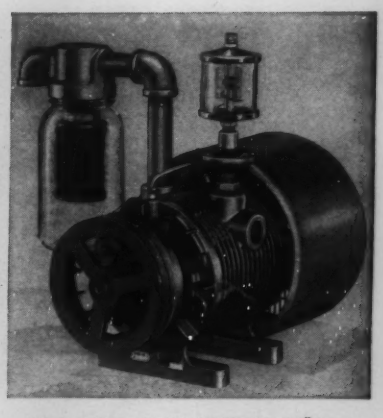
Variable Transformer

double-wound unit has isolated secondary

Powerstat LW 136 variable transformer is a double-wound assembly with isolated secondary on a single core. Absence of electrical linkage between windings permits connection as either a source of adjustable low-voltage output, limited-range line corrector, or limited-range buck-boost variable transformer. Primary consists of two windings arranged for either par-



Compressor Model 4565-P3 to 20 p.s.i.



Vacuum Pump Model 4565-V6 to 25" hg.

Big NEW 45 c.f.m. fan-cooled Model 4565

GAST rotary vane AIR PUMPS—

Twice the capacity of previous models!

COMPRESSOR

Delivers to 45 c.f.m., to 20 p.s.i.g. continuously with 5 h.p. motor at 1750 r.p.m. At lower pressures, 3 h.p. may be used. Includes automatic lubricator, felt type intake filter.

VACUUM PUMP

Delivers to 45 c.f.m., vacuum to 25 in. hg. with 3 h.p., 1750 r.p.m. For 35 c.f.m. at 1350 r.p.m., 2 to 3 h.p. is adequate. Has heavy-duty lubricator and exhaust muffler.

WRITE TODAY for Bulletin 557-VP with performance data.

Here's new, bigger-volume air pump utility—for original equipment or plant use! Built for continuous, heavy-duty service as either a Compressor or Vacuum Pump, the Model 4565 eliminates water-cooling headaches. It's air-cooled by a 10" diameter pitch fan enclosed by cowl-guard which directs cooling air and insures safety by covering fan mounted on shaft extension.

Long-lived, efficient 5-vane rotary design delivers a positive displacement of pulseless air. No air tank is needed on compressor.

Pump is easy to mount. Drive with double v-belts eliminates precision alignment problems, and fan on pulley adds extra cooling capacity. Heavy ball bearings, with double row on drive end. Pump weight approximately 92 lbs.

Investigate Gast Model 4565—it may solve a problem for you! Gast Manufacturing Corp., P.O. Box 117-P Benton Harbor, Michigan.

SUGGESTED APPLICATIONS

As volume source of low pressure air or vacuum, independent of plant air lines. COMPRESSOR: For air atomizing No. 5 or 6 fuel oil on burners for packaged boilers to 500 h.p., etc. VACUUM PUMP: Does the work of two smaller pumps for paper or sheet feeding to printing presses, packaging, labeling or bottle-filling machinery. Suitable for pipe-line milking machines, and for vacuum-forming large plastic sheets. Recommended for dry vacuum only.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Circle 484 on page 19

"MACHINERY ANALYZER saves us $1000 per hour..."

"We've had total savings of more than $100,000 since we purchased the analyzer three years ago. The analyzer has been shipped over 100,000 miles by air, rail, and car to our eight plants without need for repairs or replacements" — reports a leading chemical processor.

The Machinery Analyzer — actually a portable IRD Vibration Analyzer — is used for . . .

- TROUBLE-SHOOTING — to pinpoint faulty components exciting vibration *without costly dismantling.*
- MEASURING DISPLACEMENT — to accurately determine the condition of machinery *without costly dismantling.*
- IN-PLACE BALANCING — to dynamically balance at operating speed the accessible rotating components *without costly dismantling.*

Here are several examples cited by company officials:

- Detecting a broken gear in an important gear reducer saved a major loss of production.
- Savings of $2000 in balancing a ringer assembly because dismantling and loss of production were eliminated.
- A 450 HP motor was balanced, in place, at savings of $8000 to $10,000 in production and maintenance costs.

What portable IRD Vibration Analyzers are doing for this company — to reduce inspection, maintenance, and production costs — it can do for your company.

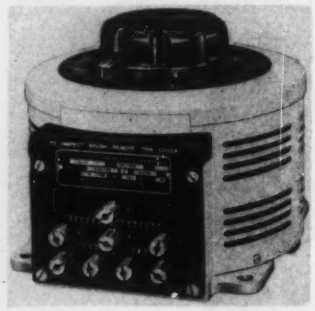
IRD

For further information — or an actual demonstration on your own machinery by an IRD field engineer — write today to International Research and Development Corporation 797-MD Thomas Lane, Columbus 16, Ohio.

Circle 485 on page 19

New Parts

allel or series connection. On any single-phase unit, secondary can be used as an isolated output rated 0 to 30 v, 25 amp, or 15-0-15 v,



35 amp. It is offered in manual or motor-driven models. **Superior Electric Co.,** Dept. LW, 83 Laurel St., Bristol, Conn.

Circle 645 on page 19

Self-Adhesive Trim

in variety of embossed patterns and colors

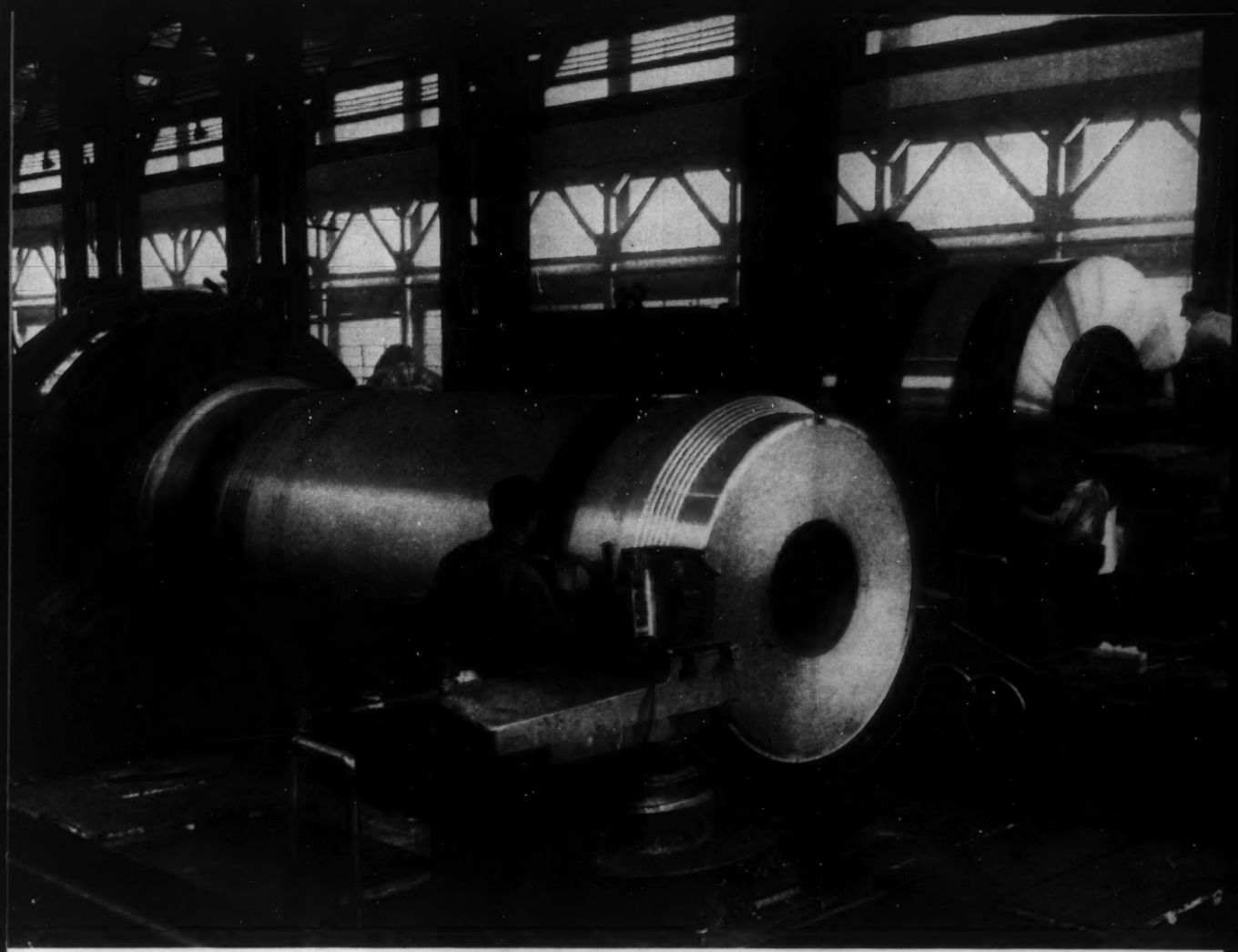
High-tack, pressure-sensitive Mylar adhesive sticks to any clean, smooth surface. It resists stains, chemical action and abrasion, and will not fade or tarnish. Material is available in a variety of embossed patterns and colors, including chrome, brass, gold and copper. It is flexible and can be printed and die-cut with standard printing equipment. **Fasson Products,** 250 Chester St., Painesville, O.

Circle 646 on page 19

Timing Motor

for display applications

Permanent-magnet synchronous motor, with torque of 30 oz-in. at 1 rpm and 60 cps, is used for a variety of timing applications, including advertising display. Mo-



Here's where the Heavyweights Shape Up

This is the No. 8 Machine Shop of our Bethlehem, Pa., plant—a shop that has seen some of the world's heaviest forgings come and go. Here giant forged parts are machined to precise dimensions, checked and rechecked, groomed and pampered.

The two cylinders in the photograph are typical Bethlehem press forgings of the heavyweight class. The one in the foreground is the main cylinder for a 3500-ton extrusion press. It has an overall length of approximately 15 ft and an OD of 6 ft 1 in. It weighs 66 tons. Its squat neighbor in the background, shorter and several tons lighter, is intended for another type of press.

Forgings of this kind always take weeks to produce. The making of the steel, the forging, the heating and cooling, the slow, careful machining—all are steps demanding the highest technical skills.

But not all Bethlehem skills are reserved for the making of heavy-tonnage items. Bethlehem shops produce every size and type of steel forging ever required—right down to the midgets weighing only a pound or so. When you are next in the market, by all means give us a call.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 486 on page 19

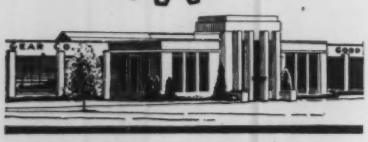
BLACK WEDNESDAY at KNICKERBOCKER TRUST . . .

For the first 9 months, 1907 was the most prosperous year the United States had experienced — and then quite suddenly, on Wednesday, October 23rd, the big Knickerbocker Trust Company of New York failed after an unexpected wave of withdrawals exhausted their supply of cash. Immediately, other banks all over the Country suffered runs and failed. People rioted in the Bronx. Industrial firms were forced to use "John Doe Checks" (checks made payable to "John Doe," meaning 'cash') to meet payrolls, and merchants and others accepted these in lieu of cash. Almost overnight the Country went from boom to bust.

In this unfavorable atmosphere, John Christensen and Soren Sorensen came to Cincinnati to start their gear business. They weathered this storm and many others in the ensuing fifty years, and today The Cincinnati Gear Company is one of the Country's leading suppliers of custom gears. In fact, we won't take a back seat to *anyone* when it comes to quality and workmanship, as our many satisfied customers will attest. Why not try us for *your* next custom gear order?

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
Fifty Years of "Gears—Good Gears Only"

CINTI®



Circle 487 on page 19

New Parts

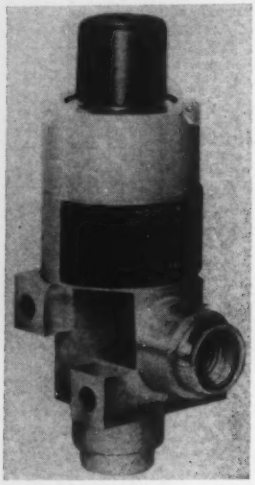
tor is available with output shaft speeds from 1 to 60 rpm and for 120 or 240-v operation at 50 and 60 cps. Models for either clockwise or counterclockwise rotation are available. **Haydon Mfg. Co. Inc.**, 245 E. Elm St., Torrington, Conn.

Circle 647 on page 19

Solenoid Valve

is miniature shut-off type

MV-126B miniature solenoid shut-off valve has no moving seals. It is operated by a 24 v dc, 1 amp power supply at pressures from 0 to 500 psi and temperatures from −65 to 350 F. Unit is used in fuel-



starter systems, hydraulic, desiccator and steam systems. Flange, plug-in, and line-mounted types are available. **Marotta Valve Corp.**, 330-80 Boonton Ave., Boonton, N. J.

Circle 648 on page 19

Subminiature Relay

has high contact rating

Subminiature relay occupying 0.18 cu in. of space has ⅛-in. silver or palladium contacts which handle 3-amp standard resistive load, and 4 amp intermittent. Basic design incorporates a permanent magnet in an electromagnetic circuit of high efficiency and performance. Relay is constructed with balanced armature having no pivots, hinges or bearings. Three types are avail-

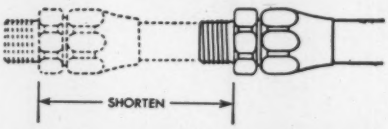
Aeroquip Engineering Notes

B. A. MAIN, JR.

The advertisement at the right says you can save money if you buy Aeroquip Hose Lines. Let's see how right this statement is.

Consider the production line along which a product using hose of Teflon is assembled. Your purchasing department will buy anywhere from three to six months' supply of hose lines to feed the production line. In this day and age of rapid change, it is pretty much a foregone conclusion that some engineering revision or modification will be required on the product.

Where these changes affect the hose lines, if you purchased Aeroquip Hose Lines originally, the detachable, reusable hose fittings always used by Aeroquip make it possible to rework the hose lines. Should the hose lines need to be shortened, it is simple to remove one of the hose fittings, cut the hose to the proper length and re-assemble. If the hose



line needs to be longer, a new piece of hose can be installed easily, using the same fittings over again. This can be done in your plant by your own people, or if our costs are lower —as they might be if the quantity of lines to be reworked is large—you can have them reworked by us.

The advertisement shows the proportion of cost of a hose fitting to the cost of the hose assembly. This proportion varies with the complexity required in the hose fitting. A fitting composed of complicated bends of rigid tubing, with perhaps one or two bosses welded into it, may run several times the cost of the hose itself. In any case, simple or complicated, the cost of the fittings will usually exceed the cost of the hose.

If you purchase hose lines with permanently attached hose fittings, no rework is possible and you must pay at least double for the privilege of making an engineering change. If you purchase Aeroquip 2802 Hose Lines made of Teflon you can, as the ad says, save money—often more than half of what new hose lines would cost you. And, you can buy the Aeroquip Hose Line with its Detachable, Reusable ***"super gem"*** Hose Fittings at prices competitive with the price you pay for hose lines made of Teflon with permanently affixed hose fittings.

B. A. Main Jr.

VICE PRESIDENT, ENGINEERING
AEROQUIP CORPORATION

Circle 488 on page 19

Hose assembly pictured has male pipe and JIC swivel fittings for industrial applications. Aircraft hose lines use more complicated fittings that represent a much higher percentage of the total hose line cost.

Aeroquip 2802 Hose Lines (Teflon*) Cost Less

BECAUSE "*super gem*" FITTINGS ARE REUSABLE

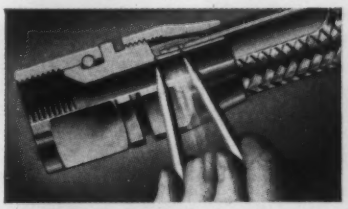
Hose lines made of Teflon excel where applications require lubricity, non-adhesion of sticky or viscous materials, resistance to temperatures up to 500° F., chemical inertness and extra long wear. Admittedly, these hose lines are expensive, but their true cost cannot be determined by purchase price alone. Hose lines of Teflon with permanent-type, swaged-on fittings are priced competitively with Aeroquip 2802 Hose Lines (Teflon), but Aeroquip "*super gem*" Fittings are reusable and can be salvaged. And the fittings are the most expensive part of any hose line!

Because it had purchased a "production quantity" of hose lines made of Teflon with permanently attached fittings, one company was forced to scrap more than $100,000 worth of hose lines due to a single engineering change. With Aeroquip 2802 Hose Lines, the "*super gem*" Fittings could have been salvaged and reused with savings of thousands of dollars.

Not only do "*super gem*" Fittings give Aeroquip 2802 Hose Lines cost-cutting advantages, they assure the ONLY leakproof, ageless assembly of fitting and hose of Teflon. Want more information? Mail this coupon:

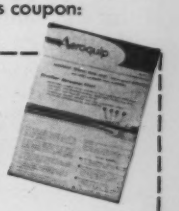
Aeroquip 2802 Hose (Teflon) and "*super gem*" Fittings can be assembled by hand in a few minutes. No expensive swaging machine is needed. A wrench and vise do a perfect job.

"*super gem*" is an Aeroquip Trademark.



Cutaway of "*super gem*" Fitting with metal-to-metal line seal pointed out at left and lip seal at right. Together, these features assure permanent protection against leakage.

*DuPont trade name for its Tetrafluoroethylene resin.



Aeroquip Corporation,
Jackson, Michigan

Please send me the following information on reusable "*super gem*" Fittings and Hose made of Teflon:

- ☐ Industrial Engineering Bulletin IEB-26A.
- ☐ Aircraft Engineering Bulletin AEB-13.

Name_____

Title_____

Company_____

Address_____

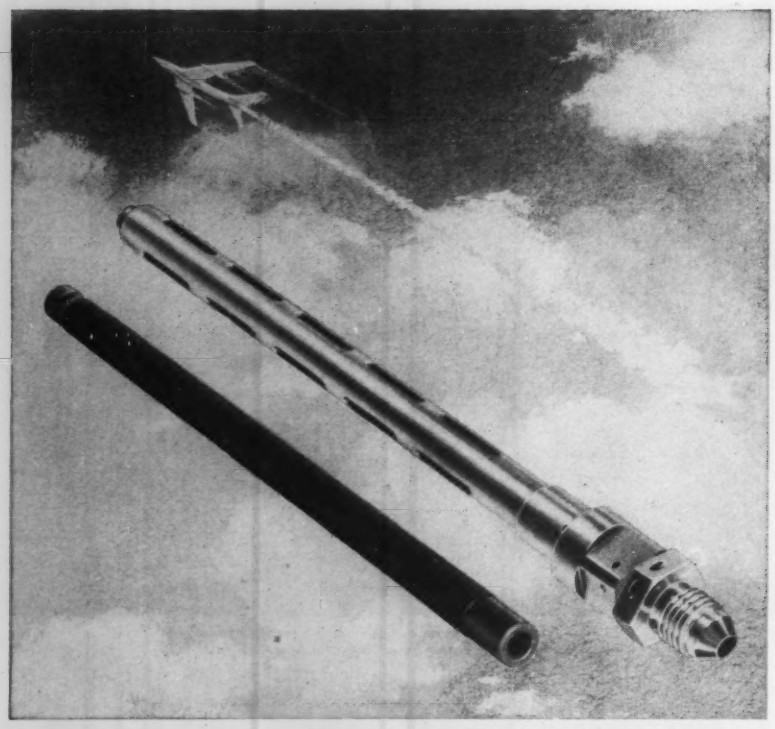
City_____ Zone____ State____

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO; WESTERN DIVISION, BURBANK, CALIF.;
MARMAN DIVISION, LOS ANGELES, CALIF.; GENERAL LOGISTICS, PASADENA, CALIF.; AEROQUIP (CANADA) LTD., TORONTO 10, ONTARIO.



"FEVER THERMOMETER"

for supersonic jets

In order to break sound barriers, jet engines must break some temperature barriers, too—which brings some real problems in material selection. Any thermostatic control in the jet stream must withstand temperatures of 2000° without significant change in properties and characteristics.

Faced with this problem, one of the world's leading designers and manufacturers of aircraft components and systems has made Kennametal* a "Partner in Progress"—and has found an answer. For a vital part of the sensing element in a thermostat assembly, a small tube of Kentanium* is used. This material, one of a big family of unusual carbides developed by Kennametal, retains its responsiveness and reliability through the entire flaming range of operating temperatures.

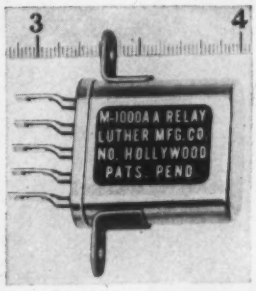
Perhaps you have some new product in mind that is still on the drawing board for want of materials with the necessary properties to meet an unusual operating condition. If you need superior corrosion or erosion resistance, hardness, strength and stiffness, or resistance to elevated temperatures, chances are you can find the needed combination of properties in the Kennametal line. Just write, outlining your problem, to KENNAMETAL INC., Department CE, Latrobe, Pa.

*Kentanium and Kennametal are the trademarks of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

C-3044A

INDUSTRY AND
KENNAMETAL
...Partners in Progress

New Parts



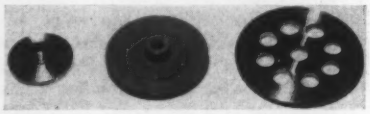
able, all hermetically sealed, which withstand shock of 100 *g*. Relay has either solder lugs or printed-circuit leads. **Luther Mfg. Co.**, 7312 Varna Ave., North Hollywood, Calif.

Circle 649 on page 19

Gear Blanks

in 1/8, 3/16 and 1/4-in. bore sizes

Precision gear blanks of No. 303 stainless steel, aluminum, phenolic, nylon and bronze are available in pin, clamp, flat and hubless types. Hubless blanks are useful for application as special gears, dials, sectors, cams, knobs, cranks and Geneva motions. Bore sizes are



1/8, 3/16 and 1/4-in. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, N. Y.

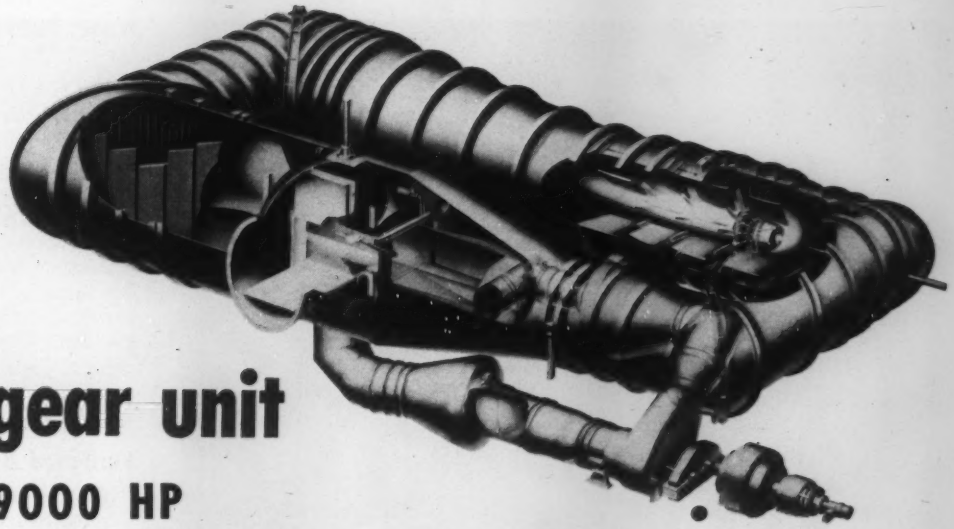
Circle 650 on page 19

Shaft Position Transmitter

has infinite resolution

Spiralpot position transmitter is an accurate unit having infinite resolution and null point at center of rotation. Instrument consists of standard three-turn, slide-wire potentiometer incorporating fixed resistors wired in a bridge circuit. One leg of bridge is shunted with

Circle 490 on page 19



Farrel® gear unit

transmits 9000 HP to transonic wind-tunnel compressor

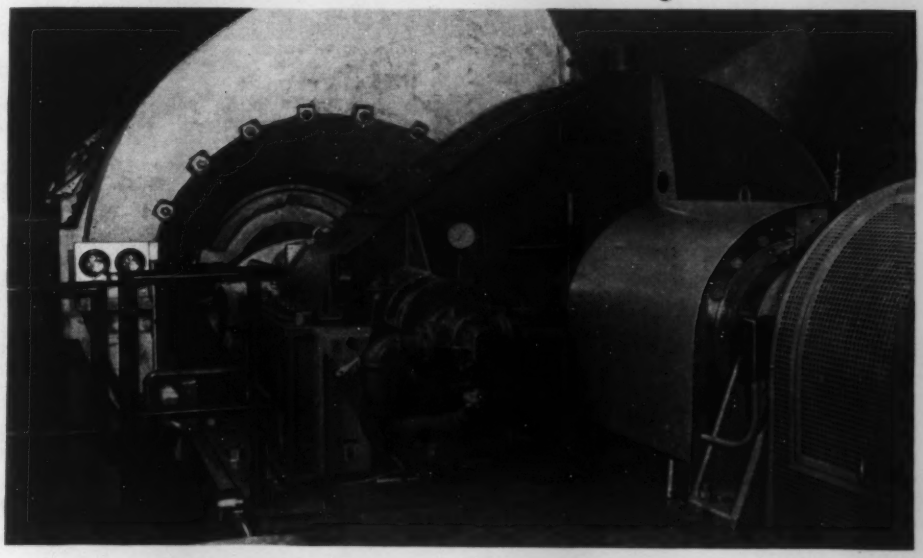
One of the important test facilities in the aviation industry is the eight-foot transonic wind tunnel at Cornell Aeronautical Laboratory, Buffalo, N. Y. In the tunnel's auxiliary system, an axial-flow compressor withdraws air from the boundary area of the test section to prevent the effect of shock waves on models being tested. This machine is driven by a 9000 HP electric motor through a Farrel speed increaser.

The Farrel unit, which is actually capable of transmitting 1200 HP, is equipped with a single pair of continuous-tooth herringbone gears. Both gear and pinion were completely finish-machined on their shafts to insure concentricity of pitch diameters with axes of rotation. Teeth were lapped to provide the smooth working surface so essential in high-speed operation.

This is typical of the painstaking care that goes into the making of every Farrel gear unit. It's a good reason to choose Farrel when you need a gear unit for high-speed service.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT
Plants: Ansonia & Derby, Conn., Buffalo & Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston
European Office: Piazza della Republica 32, Milano, Italy

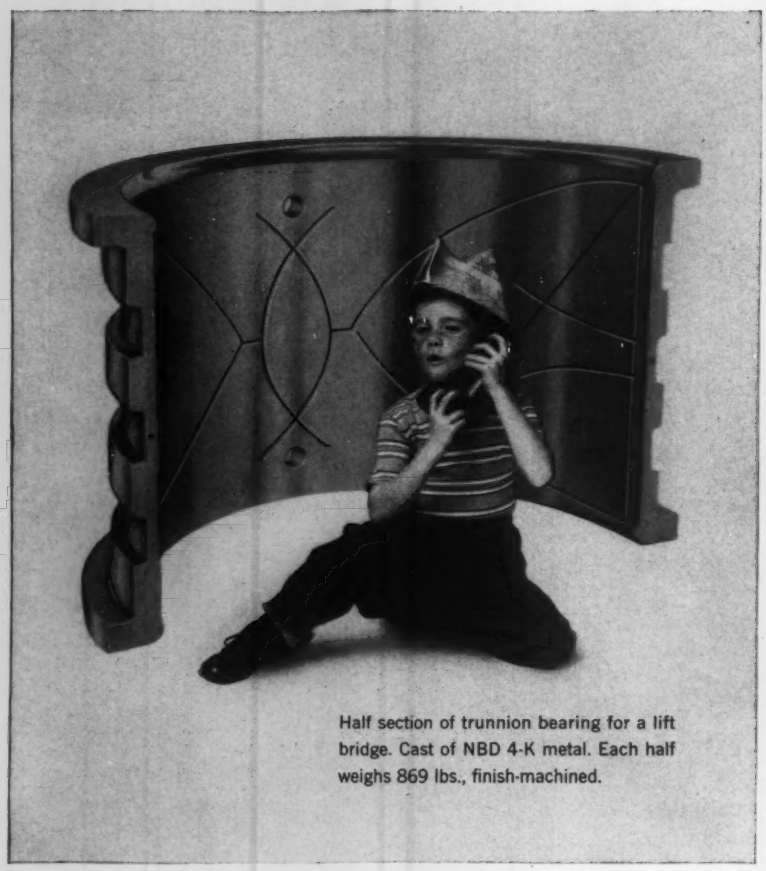
Farrel-Birmingham®



Farrel gear unit steps up the shaft speed of a 9000 HP motor from 570 RPM to 2838 RPM at the output side. Output shaft is connected to compressor — designed to move 600,000 cubic feet of air per minute.

FB-1122

Circle 491 on page 19



Half section of trunnion bearing for a lift bridge. Cast of NBD 4-K metal. Each half weighs 869 lbs., finish-machined.

CALL IN **NBD**
FOR BIG **BRONZE**

Need "big bronze" like this, with oil holes and grooves cast right in? We cast and machine them to tolerances precisely held to your specifications. That's one advantage you gain through NBD's unsurpassed knowledge of casting techniques and machining facilities.

On smaller sizes or production runs, too, you can depend on top quality from NBD. Our specialty is bronze metallurgy . . . we've developed more than 40 special alloys. And we're completely equipped for shell-mold, cast-to-size, centrifugal casting . . . as well as sand casting.

For bearings, bushings, gear blanks, pump parts, call or write us for quotes or information.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
4930 Manchester Avenue • St. Louis 10, Missouri
PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

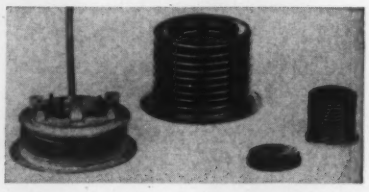
New Parts

variable section, and output can be read on a sensitive light beam galvanometer. Linearity over ±360-deg rotation is ±0.11 per cent. Over the entire ±540-deg range, linearity is ±0.37 per cent. Corosion-resistant shaft is supported in miniature ball bearings, and indexing pin is provided for precise panel alignment. **G. M. Giannini & Co. Inc.**, 918 E. Green St., Pasadena 1, Calif.

Circle 651 on page 19

Flattened Bellows

for use in miniaturized components



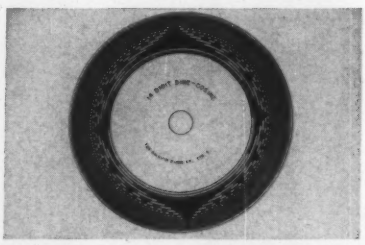
Formset bellows have been reduced in length as much as 90 per cent, yet retain original spring rate and stroke. Units are useful in miniaturized components and for aircraft parts. They have also been used where short bellows of extremely low spring rate are needed. Shown in photo are two flattened bellows (foreground) compared with two standard units. **Robertshaw-Fulton Controls Co.**, Bridgeport Thermostat Div., Milford, Conn.

Circle 652 on page 19

Code Disks

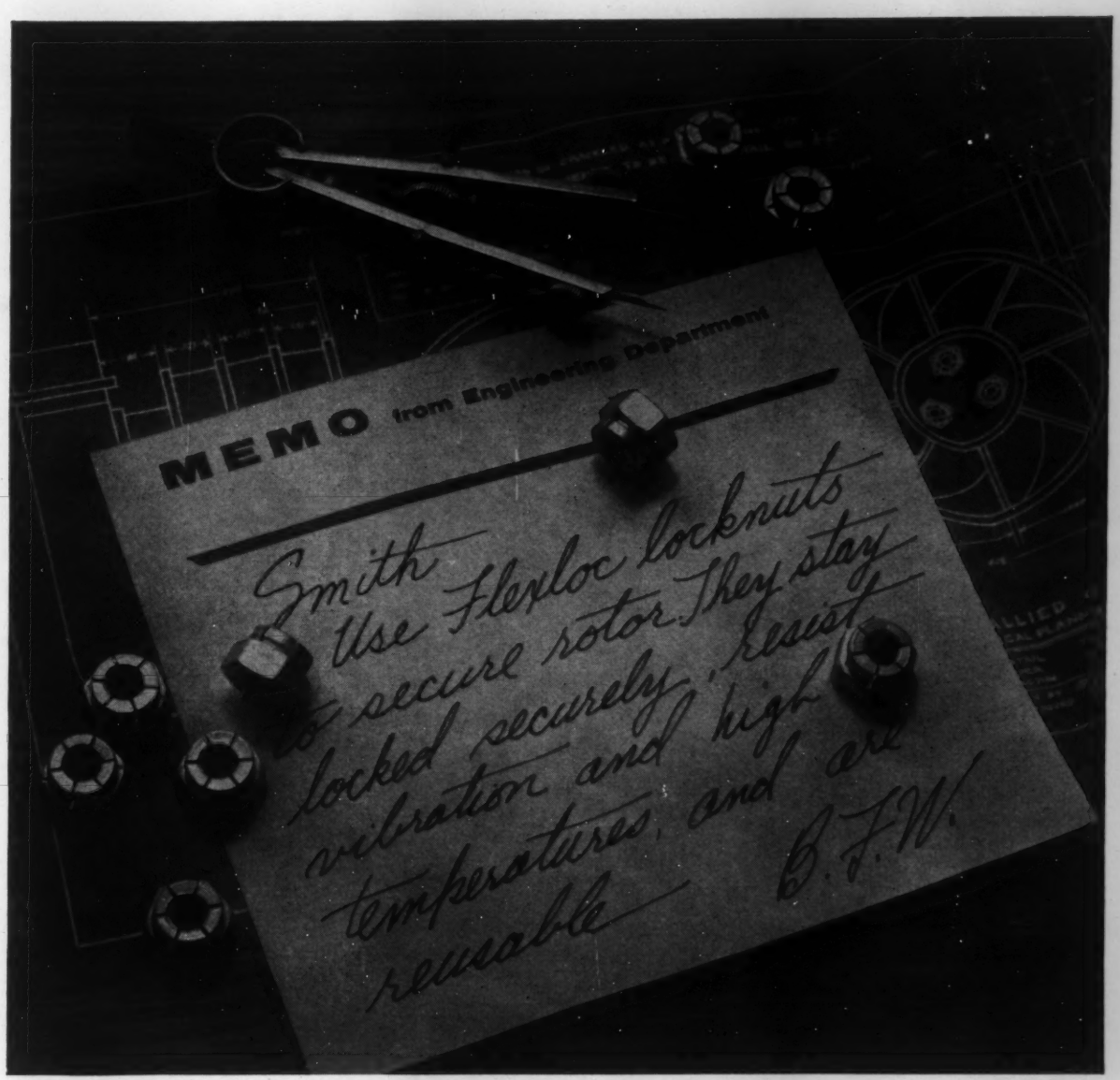
for analog-to-digital shaft angle encoders

High-accuracy disks for nonlinear and decimal codes can be mounted



in standard 6 and 9-in. encoder housings. Patterns for trigonometric functions, logarithmic functions

Circle 492 on page 19



Vibration won't loosen FLEXLOC self-locking nuts

Where products must be reliable . . . must stand up under vibration, temperature extremes and hard use . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting locking action. And they are reusable: repeated removal and replacement, frequent adjustments, even rough screw threads will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes, types and materials to meet the most critical locknut requirements. Your local industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC® LOCKNUT DIVISION

SPS

JENKINTOWN PENNSYLVANIA

Circle 493 on page 19

1. Heavy duty, reinforced design housing for permanent alignment, rigid shaft support.
2. One mesh per reduction—fewer moving parts.
3. Broad faced helical gearing—high quality, accurately hoobed for greater strength, durability. Uniform tooth deflection under load . . . no uneven wear.
4. Shafts firmly held in place. Positive gear location assures full tooth engagement across entire face.
5. Smooth, overlapping mesh, close backlash tolerances, no oil trap provide quiet operation, less heat generation.
6. Heavy duty, anti-friction bearings. Conservatively rated for wide range of operation.

Capacities to 1550 H.P.

★ Single, Double, Triple Reductions
★ Standard Ratios from 2.08 to 1 up to 360 to 1
★ 9 Shaft Arrangements

There's more capacity, greater stamina and longer service life built into Foote Bros. Maxi-Power Parallel Shaft Drives. Simple, balanced design, fewer moving parts, heavy duty construction, efficient lubrication and conservative ratings make Maxi-Power drives the logical choice for critical applications and severest operating conditions.

You can depend on Maxi-Power Drives to produce maximum performance with minimum attention because they're built for just that kind of service.

Write for Engineering Manual MPB—has complete details and selection data. There's no obligation.

this trademark stands for the finest industrial gearing made

FOOTE BROS. Duti-Rated LIFETIME GEARING

T. M. REG. U. S. PAT. OFF.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 South Western Boulevard Chicago 9, Illinois

Circle 494 on page 19

New Parts

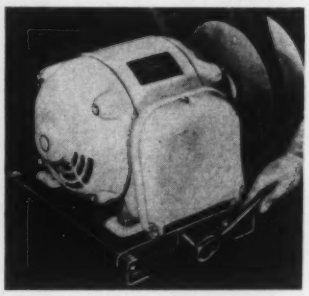
and other nonlinear codes can be produced. Decimal code disks have any number of divisions through 100,000. Shown is nonlinear sine-cosine disk. **Baldwin Piano Co.**, Industrial Sales Div., 1801 Gilbert Ave., Cincinnati 2, O.

Circle 653 on page 19

Motor Base

permits belt take-up by one-screw adjustment

Adjusto-Slide motor base accommodates NEMA frame sizes from 182 through 326V in both old and new designations, from 1 to 30 hp. Belt take-up is accomplished by adjusting only one screw and without stopping motor. Die-formed top and bottom members slide freely and maintain perfect belt



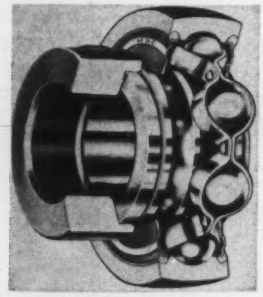
alignment. Base can be mounted vertically, horizontally or in inclined position. Adjustment screw cannot rust out or freeze up. **American Pulley Co.**, Power-Transmission Div., 4200 Wissahickon Ave., Philadelphia 29, Pa.

Circle 654 on page 19

Ball Bearings

for power-transmission use

RA Series power-transmission ball bearings are for installations requiring economical mounting of prelubricated bearings which require minimum maintenance and provide maximum protection against entrance of dirt and moisture. Bearings fit standard pressed-steel flangette housings, and bores fit commercially-ground inch shafting. Eccentric collar locks bearing firmly to shaft. Bearings have either cylindrical or spherical profile of outer ring. Spherical outer ring permits bearing to adjust itself in corresponding spherical



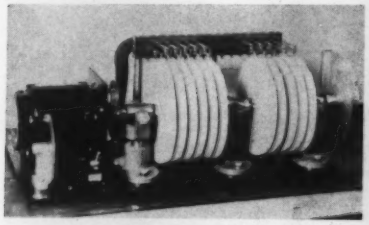
housing seat. Bearings are prelubricated; seals retain lubricant and exclude dirt, grit and moisture. **Marlin-Rockwell Corp.**, 402 Chandler St., Jamestown, N. Y.

Circle 655 on page 19

Sequence Programmer

incorporates adjustable Nylon cams

Ten-circuit sequencer, incorporating 6-in. diam adjustable Nylon cams, provides automatic testing device for capacitors and other electrical apparatus requiring production inspection. Timer includes selector switch for operation from either 115 or 230 v. Complete cycle is generated by cam shaft in 6 seconds, and settings of cams are changed by adjustment of lock-type bushings. Switches are rated for 15 amp. Gear trains are



available with variety of motors to accommodate timing cycles from a few seconds to several days in duration. **Automatic Temperature Control Co. Inc.**, 5200 Pulaski Ave., Philadelphia 44, Pa.

Circle 656 on page 19

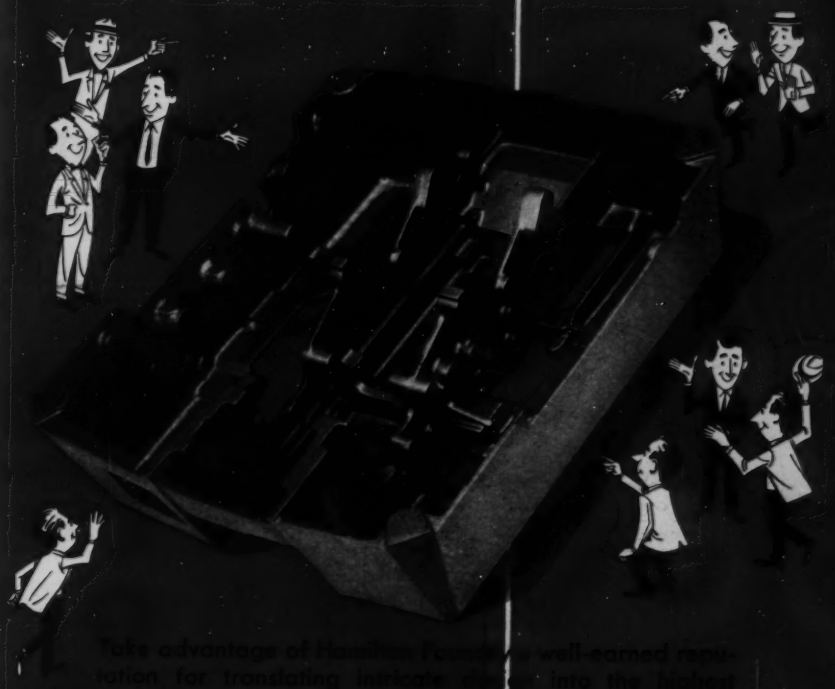
Globe Valve

is motor operated

Motorized valve is easily adaptable to many applications, such as heating, air-conditioning, processing and original equipment. It is available in ten sizes from ¼ to

Circle 495 on page 19→

HQC* is the answer for today's intricate castings



Take advantage of Hamilton Foundry's well-earned reputation for translating intricate designs into the highest quality castings.

Engineering know-how and long experience effectively solve such casting problems as wide range of metal sections and tight dimensional tolerances. Hamilton Foundry's modern production processes build economy into your castings . . . better machinability . . . skin-smooth surface . . . consistent physical properties. In addition, a variety of irons provide unusual flexibility of property ranges to meet your specifications exactly.

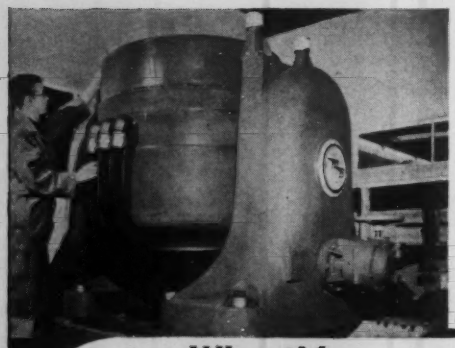
Why don't you call Hamilton Foundry today?

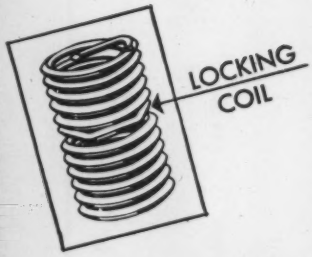
*HAMILTON QUALITY CASTINGS

GRAY IRON
ALLOYED IRON
MEEHANITE®
NI-RESIST
DUCTILE NI-RESIST
NI-HARD
NODULITE®

HS7-4

THE HAMILTON FOUNDRY AND MACHINE CO.
1551 Lincoln Avenue • Hamilton, Ohio
Phone TWinbrook 5-7491





Why this
CRITICAL VIBRATION TEST EQUIPMENT
Uses *HELI-COIL Screw-LOCK Inserts**
—to Hold Parts Securely
Under Extreme Shock & Vibration

*Reg. U.S. Pat. Off.

Currently the world's highest force electro-dynamic vibration exciter, the MB Model C250, made by the MB Manufacturing Co., is vital to government research in today's air age... has a frequency range of 2-500 cps., and a total force output of 25,000 lbs. It can be adapted to operate in chambers where temperatures range from −100°F to 300°F and simulated altitudes hit 125,000 feet.

Test specimens of up to 2190 lbs., subjected to accelerations of 10 g., must be securely held to the unit's moving assembly.

The thread assemblies within the vibrator, and joining test specimens to the unit, are subjected to grueling shock and vibration. Yet, even under these extreme conditions, *Heli-Coil* Screw-LOCK Inserts (277 of them) function perfectly... protect threads against stripping... hold fasteners securely.

Meeting military specifications for torque and vibration, this new, one-piece stainless steel Screw-LOCK Insert:

1. positively locks screws against loosening under impact and vibration
2. prevents thread wear, stripping, corrosion, galling, seizing
3. eliminates the need for lock-nuts, lock-wiring, and other supplementary locking devices
4. offers high re-usability on repeated disassembly and reassembly.

Heli-Coil Screw-LOCK Inserts are available in many sizes, including the new miniature 4-40. For further information, write ⊕ 4227

HELI-COIL CORPORATION
A Division of Topp Industries, Inc.

HELI-COIL CORPORATION
507 Shelter Rock Lane, Danbury, Conn.

☐ Send me complete design data on *Heli-Coil* Screw-LOCK Inserts.
☐ Who is my local *Heli-Coil* Applications Engineer?

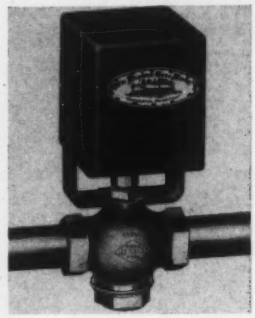
NAME_____ TITLE_____
FIRM_____
ADDRESS_____
CITY_____ ZONE____ STATE_____

IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

Circle 496 on page 19

New Parts

3 in. with voltages of 24, 115 or 230 v. Three timing cycles are available: 8, 32 and 139 seconds. Unit has automatic disk compensation, tight shut-off, 150-lb pressure capacities on most sizes, no



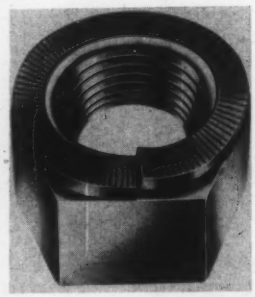
mounting restrictions and permanent lubrication. Unit can be controlled by any positive-action, single-pole, double-throw switch. **New England Gear Works,** South End Rd., Southington, Conn.

Circle 657 on page 19

Nuts and Lock Washers

have serrations on locking surface

Preassembled nuts and helical spring lock washers, with serrations on locking surface, are designated Spring-Nuts. They are



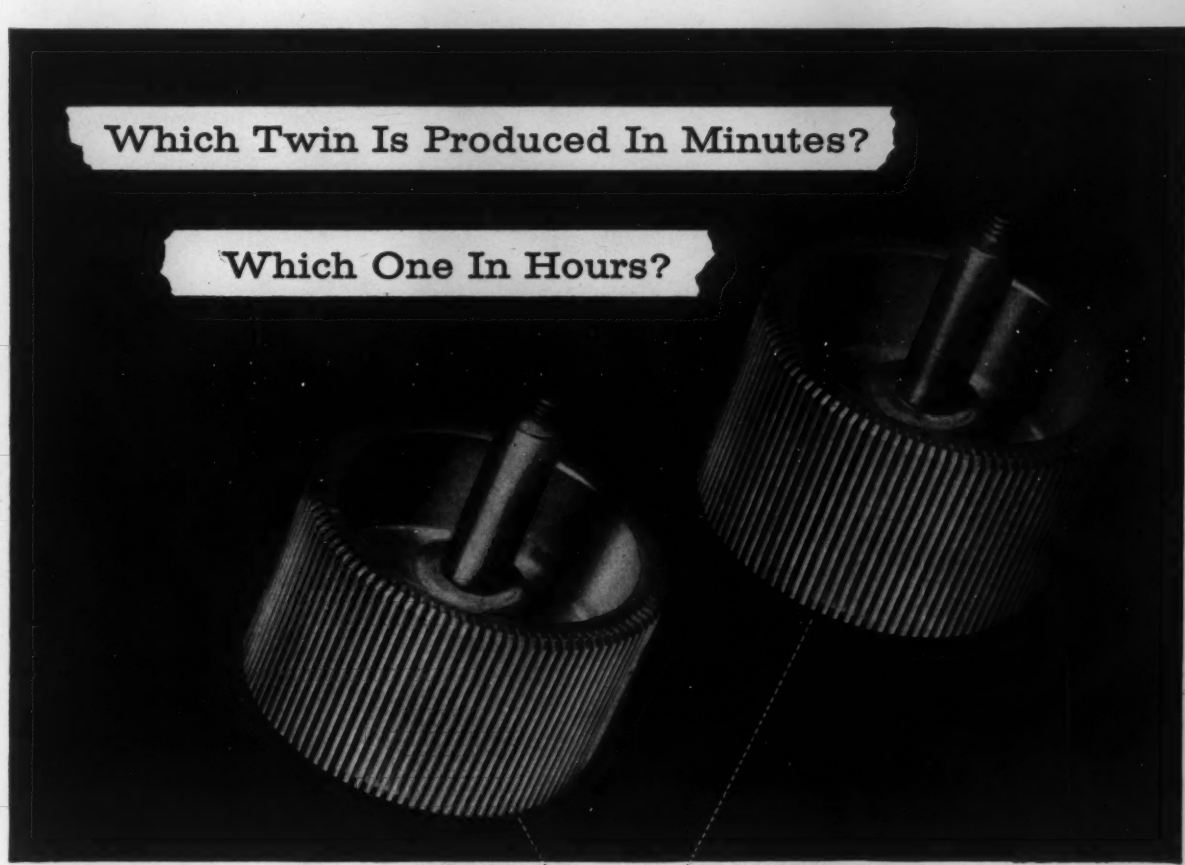
available in steel, brass, aluminum and stainless, in a range of standard sizes. **Jacobson Nut Mfg. Corp.,** Box 117, Kenilworth, N. J.

Circle 658 on page 19

Heavy-Duty Generator

provides 115-v ac power

GenerAC heavy-duty electric generator, for use with trucks and tractors, provides 115-v single-


Which Twin Is Produced In Minutes?
Which One In Hours?

PARKER SALES ENGINEERS

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

CINCINNATI 14, Ohio
William H. Broxterman • 2430 Central Parkway

DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens

GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street

KIRKWOOD 22, MO.
Edward F. Higgins, Jr. • 102 West Adams Street

LONG BEACH 11, California
R. W. Fletcher • 2803 Loomis Avenue

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

WILTON, Conn.
Girard L. Palmer • Belden Hill Road

These parts are identical. One, however, is produced in minutes, the other in hours. Parker-engineered die casting makes the difference.

Formerly, this part (shown left above) was machined from the solid. The threaded steel shank was inserted in a separate operation. Numbers on the face (not shown) had to be stamped . . . still another operation. *Total production time per piece was measured in hours.*

Now, this same part, including the steel insert and the face numbers, is produced as a unit by Parker-engineered die casting. Trimming of gate and fins is the only secondary operation. *Total production time per piece is now measured in minutes.*

Here is just another example of the way Parker-engineered die castings save you money.

This skill and experience can solve problems—and save money—on *your* components parts. Just call the nearest Parker sales engineer or write the factory direct.

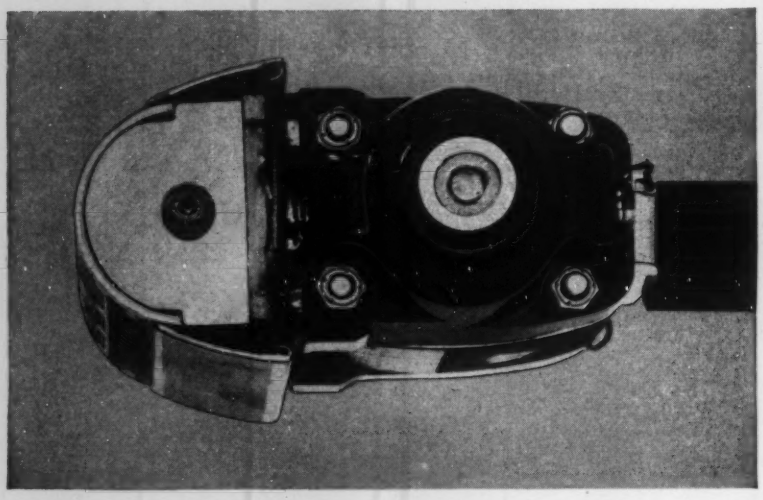
Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

Circle 497 on page 19

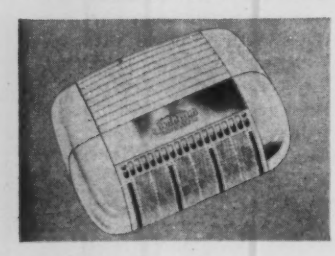
FASTENER PROBLEM



Self-locking fasteners for limited clearance applications

The cutter shaft of the Sunbeam Electric Shaver moves the cutting blades at about 9000 RPM. The double nuts previously used to fasten the pitman arm to this shaft had to be really tight. With the pressure of high volume production, improper tightening sometimes caused bent shafts—and frequent thread stripping.

A single true miniature ELASTIC STOP® nut, only .080" high and .125" across flats (ESNA No. 99-1660-12, 1-72 thread) is used to replace the double nuts. The action of ESNA's red elastic locking collar permits locking anywhere on the shaft for simple and completely accurate adjustment . . . and eliminates thread stripping. This simple, direct locking action avoids production-time losses due to bending; and saves the cost of the rejected shafts as well.



A separate series of reduced-dimension hex nuts are used on the "field" studs fastening motor to frame (ESNA No. 99-2399-38). This size 3-48 nut is .130" high and .187" across flats. The stop nut eliminates lock washers and further shortens assembly time. Solution of this multiple fastener problem illustrates ESNA's ability to supply an efficient, vibration-proof, self-locking fastener to meet almost any dimensional requirements.

MAIL COUPON FOR DESIGN INFORMATION

ESNA

Dept. N91-712, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send me the following information:

☐ Details on ESNA miniature and reduced dimension nuts

☐ ELASTIC STOP® nut bulletin

☐ Here is a drawing of our product. What fastener would you suggest?

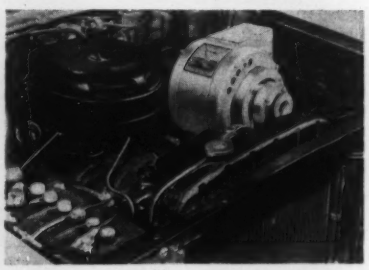
Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

New Parts



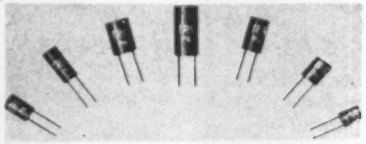
phase ac power. Designed for continuous portable auxiliary power and emergency power during service failures, it operates motors up to 2 hp. Unit is driven through an electric clutch. Generator shown provides 3500-w 60-cycle 115/230-v single-phase electric power. **Electric Controls Inc.**, Wales, Wis.

Circle 659 on page 19

Miniature Resistor

for mounting on printed-circuit panels

Type P miniature resistor is a single-ended, flat-top, encapsulated wire-wound unit designed for rapid mounting on printed-circuit panels. Seven sizes are available from ¼-in. diam by 5/16-in. long, to ⅜-in. diam by ¾-in. long. Ratings are from 0.1 to 0.4w. Unit operates in



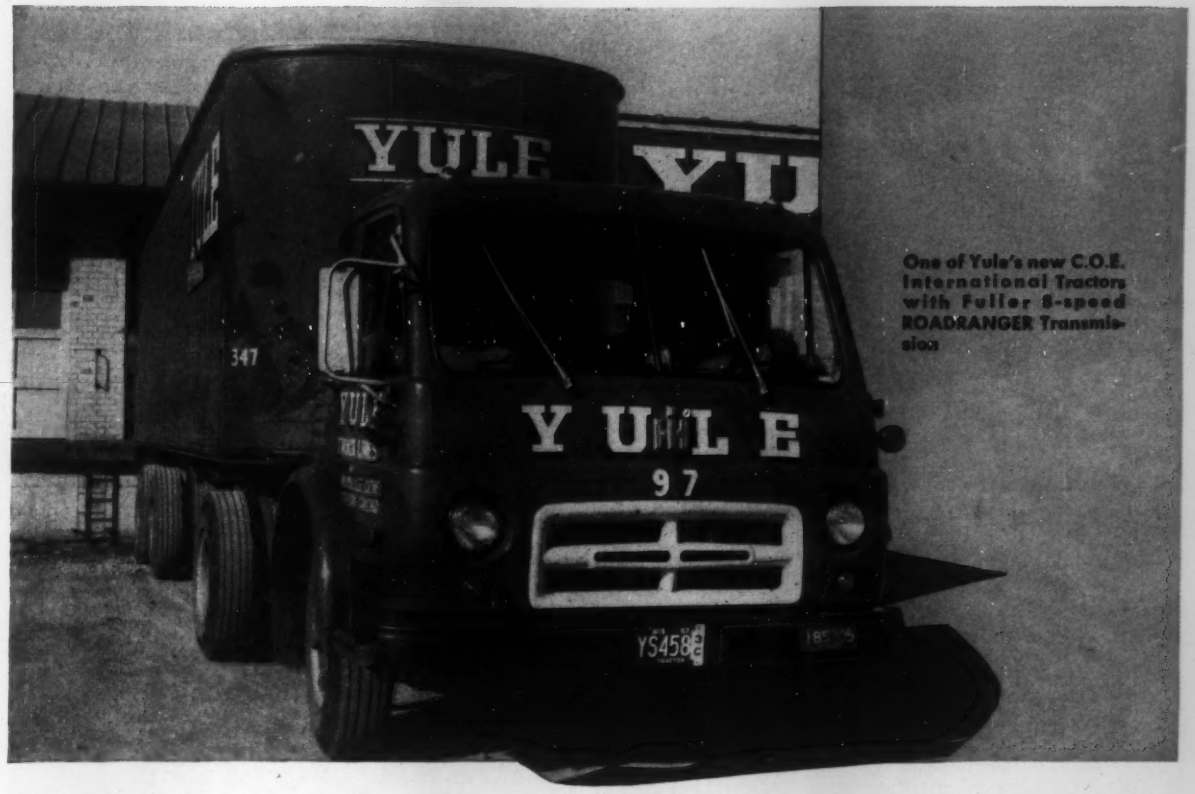
ambient temperatures to 125 C. Resistor withstands all applicable tests of MIL-R-93A, Amdt. 4. **Resistance Products Co.**, 914 S. 13th St., Harrisburg, Pa.

Circle 660 on page 19

Shaft Disconnects

have adjustable operating shafts

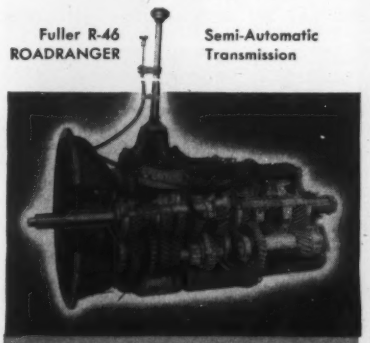
Style HCI disconnects with adjustable operating shafts are available in 30, 60, 100 and 200-amp ratings. Telescopic operating shafts eliminate need for supporting structures and compensate for differences in depth between enclosure and disconnect in control centers, switchboards, machine tool control panels and other elec-



One of Yule's new C.O.E. International Tractors with Fuller 8-speed ROADRANGER Transmission

YULE eliminates transmission problems with FULLER 8-speed ROADRANGERS®

Fuller R-46 ROADRANGER Semi-Automatic Transmission



FULLER

TRANSMISSIONS

FULLER MANUFACTURING CO. Transmission Division • Kalamazoo, Mich. Quit Drop Forge Div., Milwaukee 1, Wis. • Shafer Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest. Dist. Office, Tulsa 3, Okla.

Says V. A. Martell, President of Yule Truck Lines, Inc., Milwaukee, Wisconsin: "Fuller ROADRANGERS have eliminated all our transmission problems. We get the kind of gearing we need to take us through any kind of traffic and road condition. After continuous testing under every conceivable condition, the Fuller 8-speed semi-automatic ROADRANGER Transmission thoroughly proved itself. Our drivers say: 'This is it!' and they wouldn't have anything else."

"And," adds E. A. Jenkins, General Manager—Operations: "We will have ROADRANGERS in our future units for sure. For our operation, ROADRANGER Transmissions, C.O.E. tractors and big engines are the answer. Our maintenance superintendent credits the Fuller ROADRANGER Transmission with increased efficiency and with decreased maintenance cost."

Yule's latest fleet additions include 10 International CO-205 Tractors with RD-450 Engines, and 5 International R-195 Tractors with RD-406 Engines . . . all equipped with Fuller 8-speed semi-automatic ROADRANGER Transmissions.

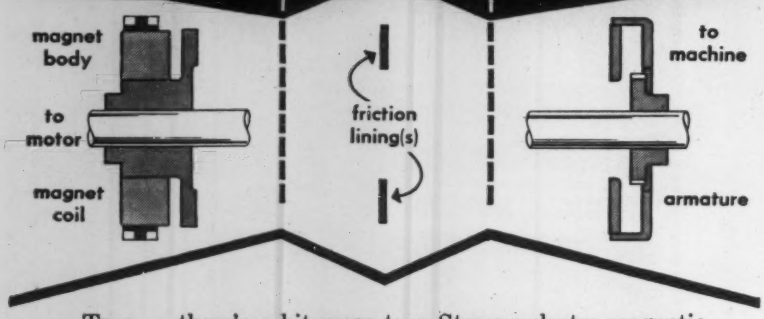
The same outstanding ROADRANGER Transmission advantages . . . low maintenance costs—easier, quicker shifts—higher average road speeds—greater fuel economy—38% steps between ratios keep engines operating in the high rpm range—less driver fatigue—space-and-weight saving economies . . . can be applied to *your* operation.

For complete details on Fuller ROADRANGERS, see your truck manufacturer or truck dealer now!

Circle 499 on page 19

Stearns electro-magnetic CLUTCHES

simple as a b c



True — there's a bit more to a Stearns electro-magnetic Clutch than you see here. BUT BASICALLY — this is it! No moving parts except friction linings. Compact, for simple installation. Low inertia to the driven end — as the driven member carries only the friction elements.

CHECK THESE FEATURES...

★ **AUTOMATIC OR MANUAL CONTROL.**
Push buttons or electric eye provide unlimited clutch application for controlling a machine and its source of power.

★ **LONG, EFFICIENT LIFE.**
No metal-to-metal contact — the only wear is on the oversize friction linings, and lining wear *increases* rather than decreases torque. Low, even pressure over a large area eliminates frequent adjustment, and costly maintenance.

★ **SMOOTH ACTION — LOW INERTIA.**
When electrical contact is closed, clutch is energized — picking up load with practically no jerk or jar to the coupled machinery.

★ **WIDE TORQUE RANGE. 0.4 to 120,000 lb ft**
— from business machines to ball mills and larger. Well over 100 standard clutch and clutch brake combinations, or custom-designed units to match your machines.

★ **SIMPLE INSTALLATION — QUICK, EASY ADJUSTMENT.**
Compact, simple design permits fast, easy installation. Armature is threaded in clutch cage, permitting you to compensate for wear in minutes. Many users report "not one cent of maintenance" — even in heavy round-the-clock operations where abrasive atmospheric conditions exist. Quiet, cool-running.

Call your local Stearns representative — or write for complete Clutch Bulletin No. 226 F.

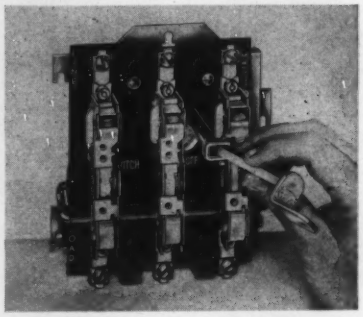
10

BRAKES MILWAUKEE Stearns WISCONSIN CLUTCHES

ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

New Parts

trical control equipment. Both standard and long-length shafts are available. Adjustable range is approximately 2 in. on 30, 60 and 100-amp switches. The 200-amp



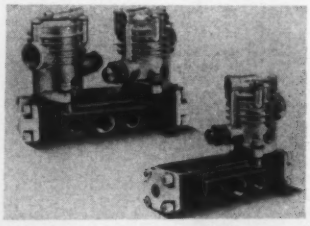
units have a range of about 5 in. **General Electric Co.**, Circuit Protective Devices Dept., Plainville, Conn.

Circle 661 on page 19

Control Valves

in single and double-solenoid types

Speed King ¼-in. four-way foot-mounted control valves are designed for control of smaller devices. They are available in both single and double-solenoid types. Solenoid coils, encased in molded epoxy resin, are guaranteed against burnout for life of valve. Pilot plungers and valve stem are only moving parts, and no springs are used in main valve body. Valves, for 30-250 psi air service, are available



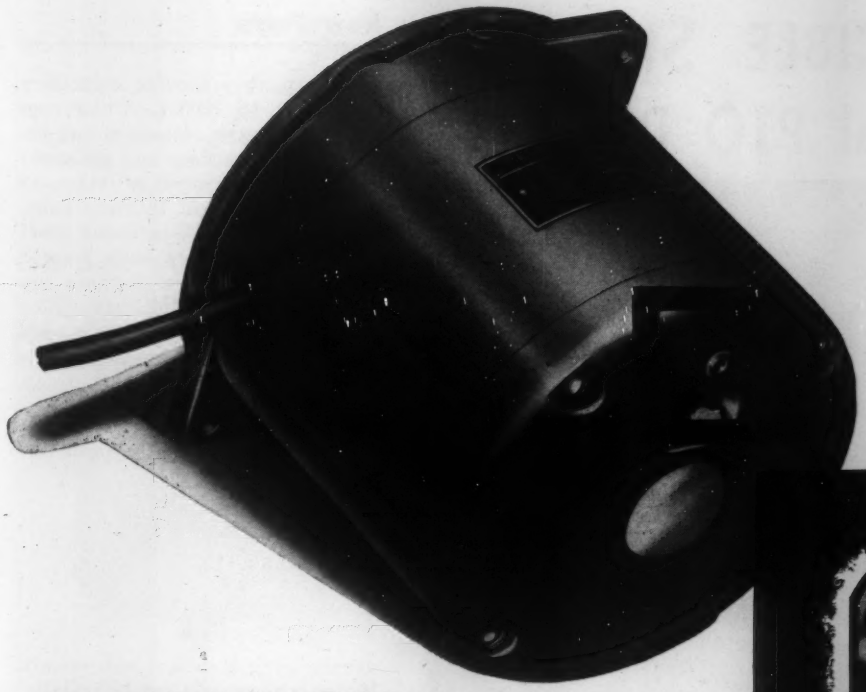
for operation on ac or dc, any voltage. **Valvair Corp.**, 454 Morgan Ave., Akron, O.

Circle 662 on page 19

Speed Reducers

are double-reduction units

Four improved standard-primary double-reduction units are available in center distances of 2, 2½, 3 and 3½ in. Coupled with proper



Klixon Manual Reset Protector as used in Marathon oil burner motor.

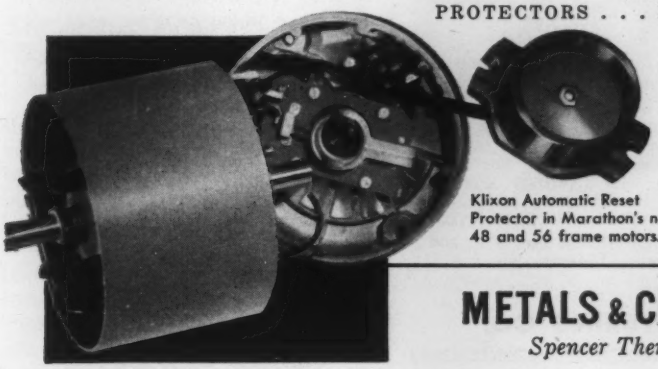
MARATHON ELECTRIC assures Customer Protection with KLIXON Motor Protectors

Marathon Electric Manufacturing Corporation, one of the leading producers of electric motors and generators, specifies and uses KLIXON Motor Protectors. With KLIXON Protectors, Marathon assures protection to the customer against nuisance tripping and costly burnout of motors.

Marathon says of their oil burner motor: *"We feel it is of real value to our customers to mark the nameplate,* 'MOTOR EQUIPPED WITH MANUAL RESET THERMAL PROTECTORS . . . PUSH RED BUTTON TO RESET.'"

Marathon also uses the KLIXON Automatic Reset Protector in many of its motors.

You, too, can help assure customer protection against burnouts, reduce service calls and repairs by specifying and using KLIXON Protectors. The additional cost is low, pays for itself over and over.



Klixon Automatic Reset Protector in Marathon's new 48 and 56 frame motors.

Now there's something new — in addition to famous KLIXON Protectors for single-phase motors, you can get full protection engineered into 3-phase motors with a single, built-in KLIXON Protector. For full details, write for Bulletin MOPR-1.

METALS & CONTROLS CORPORATION

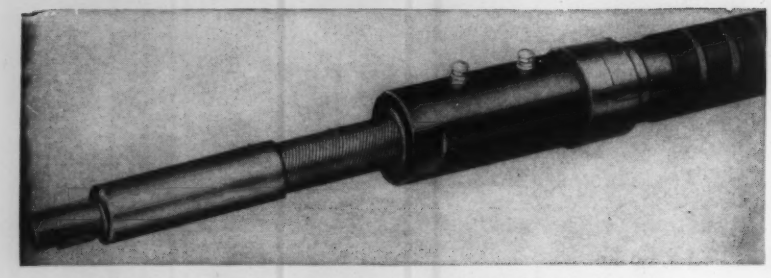
Spencer Thermostat Division

3207 Forest Street, Attleboro, Mass.

KLIXON®

STOW FLEXIBLE SHAFTING
The Ideal PTO Drive

1¼" flexible shaft under tractor-trailer transmitting 10 HP.



1¼" core assembly pulled out of casing. Note steel-backed bronze sleeve bearing.

Here are five big reasons why flexible shafting is an ideal power take-off drive on trucks and tractor trailers.

FLEXIBLE SHAFTING:

1. Can connect a drive shaft and a driven shaft which are working at different angles and located in different planes.
2. Eliminates the need for accurate alignment.
3. Eliminates dangerously exposed revolving parts; no safety guards required.
4. Replaces connections affected by vibration.
5. Is economical because it is so easy to install and maintain.

Available with built-in bearings and couplings in sizes from ¼ inch to 1¼ inches in diameter—STOW flexible shafting can help solve your trucking and maintenance problems *in advance*. The know-how of 82 years' experience goes into every STOW flexible shaft!

STOW flexible shafts are being used on trucks and tractor-trailers to:

- Operate pumps for petroleum, other liquids and hydraulic pumps on dump trailers.
- Operate conveyors for grain and coal.
- Operate compressors on refrigeration trucks.

Our Engineering Department will be glad to work with you on any special drive problems. For complete data on flexible shafting sizes, torque capacities, and other specifications, write for STOW Engineering Bulletin, No. 570, and Tractor-Trailer Bulletin, No. 542.

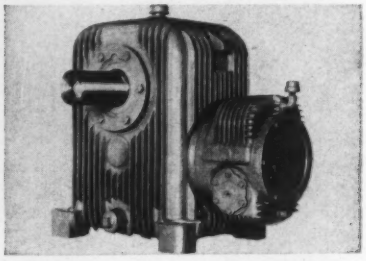
STOW

STOW MANUFACTURING CO.

11 Shear St. Binghamton, New York

New Parts

secondary, they provide reductions from 25:1 to 3500:1. Units provide wide range of torque and reduction combinations and are available with worm over or under, or gear shaft vertical in right-hand, left-hand, or double-extended shaft assemblies. Primary units from 2 through 3-in. center distance are new standard housings containing standard gearsets, bearings and caps. Secondaries are speed re-



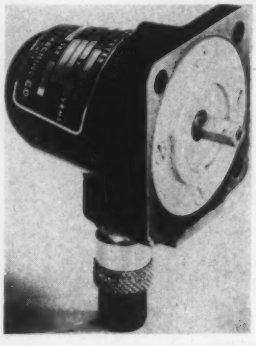
ducers using standard components. Water-cooling coils can be installed in all sizes above 3-in. center distance. Primaries and secondaries are independently lubricated and have individual breathers, fillers and oil-level gages. **Michigan Tool Co.**, Cone-Drive Gears Div., 7171 E. McNichols Rd., Detroit 12, Mich.

Circle 663 on page 19

Digital Tachometer

has accuracy of 0.001 rpm

Digital tachometer has many uses where precise rotational measurement is required, such as in instrumentation and missiles. Accuracy of instrument is limited only by read-out method employed, and can be better than 0.001 rpm on a scale of 0 to 10,000 rpm. Output can be by sharp pulse or sine wave with signal set 1 to 100 per revolution.



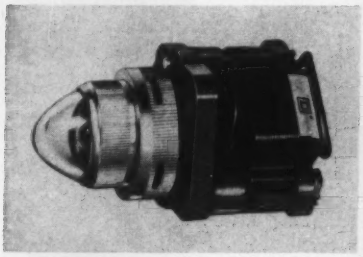
Unit is available with either single-ended or feed-through shafts, for mounting on drive pads. **Nacimco Products Inc.**, 2300 National Ave., National City, Calif.

Circle 664 on page 19

Pilot Light

has extra-brilliant cap

Oiltight pilot light with more brilliant cap offers extra resistance to chemicals and abrasion in addition to increased visibility. It is avail-



able in clear glass or plastic in one of five bright colors. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis.

Circle 665 on page 19

Extruded Tubing

of linear-type polyethylene

Extruded tubing of linear-type high-temperature, high-tensile polyethylene is available in 100-ft coils. Tubing can be obtained in all standard polyethylene sizes from ¼ through 1 in. OD with wall thickness of 1/16-in., to ¾ and 1 in. OD with wall thickness of 3/32-in. **American Agile Corp.**, P.O. Box 168, Bedford, O.

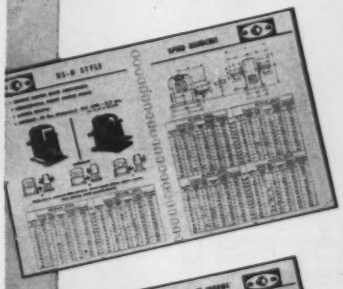
Circle 666 on page 19

Shaded-Pole Motor

is permanently self-lubricating

Series 402 shaded-pole motor incorporates a permanently self-lubricating bearing which provides automatic, positive oil circulation under high temperatures. Motor is especially useful where inaccessibility and hard use are prime factors, such as in springwire, gear, chain, rubber belt and friction drives, or to move high velocity, heater or sirocco air blowers. Twelve models are available, and

. . . is power-packed with 186 pages of complete information on how to calculate and plan the proper transmission for any drive problem. Contains valuable charts, tables and formula to help you select the right gears or speed reducers for the job.



SPEED REDUCERS

This section of the catalog gives you the specifications, dimensions and other vital information necessary to select the proper reducer in relation to required ratios, horsepower input, torque and space availability.

GEARS

This section of the catalog tabulates complete dimensions on Ohio standard spur, bevel, mitre, spiral, helical, worm and worm gears, and steel rack. Most items available with 14½ and 20 degree pressure angle.

- Contains information to which you'll constantly refer for valuable transmission ideas.

SEND FOR YOUR COPY TODAY

The Ohio Gear Company
1338 East 179 Street • Cleveland 10, Ohio

Please send me your new 1957 Gear & Reducer Catalog:

Name .....

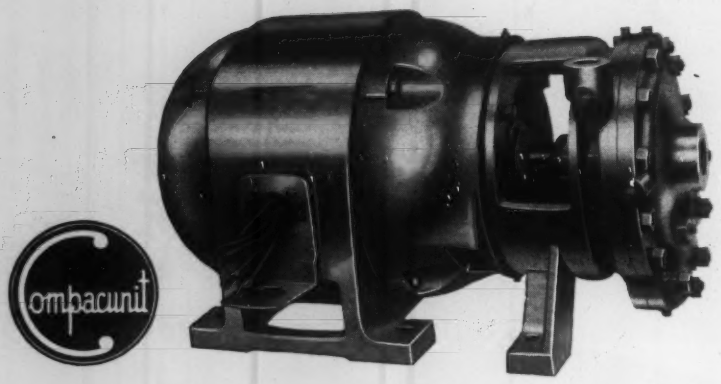
Company ..... Title .....

Address .....

City ..... Zone ..... State .....

Circle 503 on page 19

A NEW WARREN Centrifugal



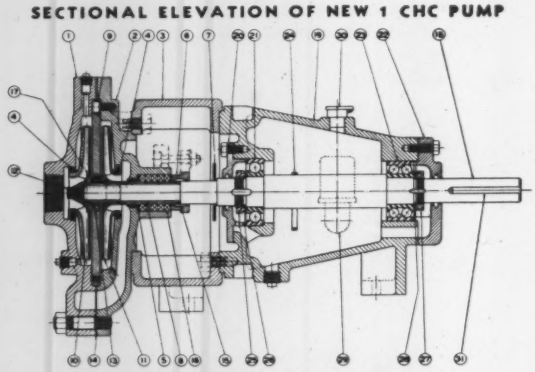
Type 1CH 2-stage pump is designed and priced for low-capacity, high head jobs

Here is another cost-saving addition to the Warren line of *Compacunit* Close Coupled Pumps.

Capacities - 5 to 60 gpm
Heads - 200 to 375 ft.

The new Warren 1 CH is important too for its simplicity and compactness . . . and every part is designed for long life and protection against wear. It is also available with a cradle mount (Type 1 CHC).

SECTIONAL ELEVATION OF NEW 1 CHC PUMP



DESIGNATIONS

1. Casing—1st Stage
2. Casing—2nd Stage
3. Frame
4. Case Ring
5. Stuffing Box Bushing
6. Gland
7. Flinger
8. Shaft Sleeve
9. Center Section
10. Impeller—1st Stage
11. Impeller—2nd Stage
12. Impeller Nut
13. Center Section Bushing
14. Gasket
15. Gasket
16. Packing Anchor No. 317
17. Impeller Key
18. Shaft

RATING CHART

1-CH or 1-CHC Bulletin									
HD	GPM	5	10	15	20	30	40	50	60
275		7½	7½	7½	7½	7½	7½	10	10
300		7½	7½	7½	7½	7½	7½	10	10
325		7½	7½	7½	7½	7½	10	10	
350		7½	7½	7½	7½	10	10		
375		7½	7½	7½	7½	10			

AVAILABLE IN THESE MATERIALS

PART	STANDARD	ALL IRON	ALL BRONZE
Suction Head	Cast Iron	Cast Iron	Bronze
Casing	Cast Iron	Cast Iron	Bronze
Impeller	Bronze	Cast Iron	Bronze
Impeller Nut	Bronze	Stainless Steel	Bronze
*Shaft	Steel	Steel	Steel
*Shaft Sleeve	Bronze	Cast Iron	Bronze
Seal Cage	Cast Iron	Cast Iron	Bronze
Gland	Cast Iron	Cast Iron	Bronze
Flinger	Cast Iron	Cast Iron	Cast Iron
Frame	Cast Iron	Cast Iron	Cast Iron

*Shaft sleeves available in Nitralloy Nitrided, Hardened Stainless steel or Monel and shafts in Stainless Steel or Monel on special order.

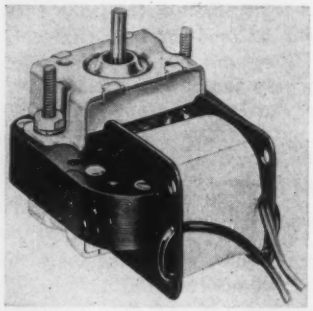
ASK FOR BULLETIN NO. 242

WARREN

G-7

WARREN PUMPS, INC.
WARREN, MASSACHUSETTS

New Parts



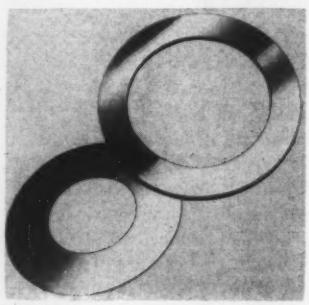
standard mounting holes permit interchangeability with other motors. **Controls Co. of America,** Soreng Sales Div., Schiller Park, Ill.

Circle 667 on page 19

Electrical Contact Rings

have low contact resistance

Gibsiloy NC-205 silver-nickel-graphite electrical contact rings provide improved performance of current-carrying hinged connections on products such as circuit breakers and disconnecting switches. Rings have low contact resistance yet will not gall despite heavy sliding action. They are available with silver-solder back-



ing. After brazing, rings can be planished to improve assembly, hardness and flatness. **Gibson Electric Co.,** Frankstown Ave., Pittsburgh 21, Pa.

Circle 668 on page 19

Vibration Isolators

for airborne equipment

L44 Lo-Mount vibration isolators for airborne equipment meet specification MIL-C-172B. Spring and friction-damping design of the mount provides low transmissibility at resonance and low natural

Circle 504 on page 19

Cleveland miniature socket screws give extra strength in compact assemblies

Cleveland miniature cap and set screws eliminate the need for designing special screws to fasten parts in compact units. In countless intricate devices – servo-mechanisms, computers, typewriters, electronic and electrical equipment–they are used as functional parts permitting significant reduction in size, weight and cost without sacrificing strength.

Dimensions are held to very close tolerances. Accurately formed hexagon sockets insure high torque, non-slip wrenching, and maximum wrench holding power. Threads are rolled for accurate Class 3 fit and to gain extra fatigue and tensile strength. Alloy steel screws are carefully heat treated to obtain optimum of 180,000 psi minimum tensile strength.

Cleveland standard miniature screws are available from stock in both high quality heat treated alloy steel and nonmagnetic 18-8 stainless. Write today for prices and a copy of the Cleveland socket screw products folder.

RECOMMENDED INSTALLATION TORQUES IN IN.-LB. FOR HEAT TREATED ALLOY STEEL SOCKET SCREWS

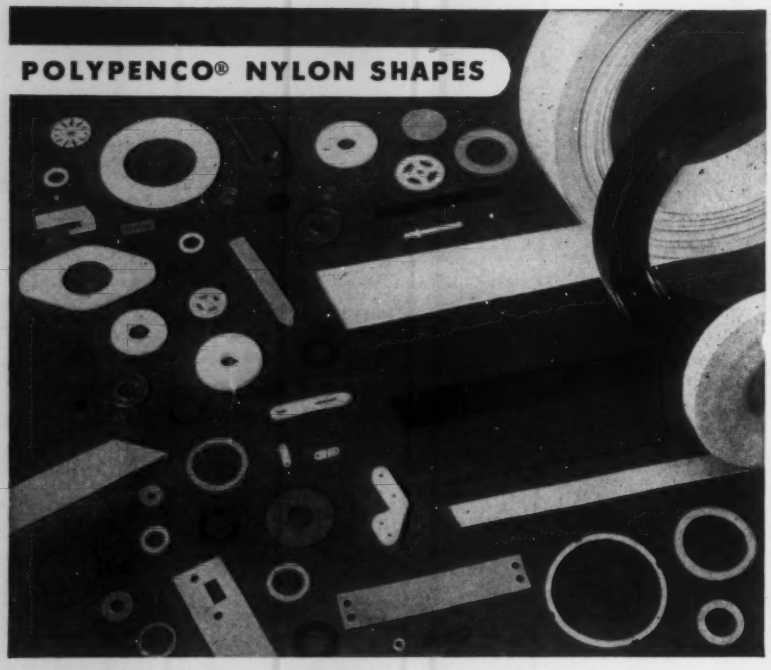
Socket head cap screws			Socket set screws, plain cup point		
Diameter	NC	NF	Diameter	NC	NF
#0	—	2.0	#0	0.5	0.5
#1	3.5	3.5	#1	1.5	1.5
#2	6.0	6.0	#2	1.5	1.5
#3	8.5	9.5	#3	5.0	5.0

THE CLEVELAND CAP SCREW COMPANY

4444-6 Lee Road, Cleveland 28, Ohio

WAREHOUSES: Chicago • Philadelphia • New York • Los Angeles

Circle 505 on page 19



Nylon in strip form offers new possibilities in component design

• Designers looking for an economical way to obtain high quality nylon parts of thin cross section, are finding their answer in Polypenco Nylon Strip. For with Polypenco Strip, production is simplified—using high speed punch presses—with low cost production rates. Polypenco Nylon Strip is produced in thicknesses of .010″ through .125″, with widths up to 4″.

OUTSTANDING PROPERTIES

Thrust washers, thin gears and other parts fabricated from Polypenco Strip are tough, long-wearing and resilient. They have a low coefficient of friction, noise dampening and non-scratching characteristics, and the pluses of chemical resistance and electrical insulating properties. Conveyor wear strips and thrust washers are available from Polymer Corporation stocks, stamped from Nylatron® GS, a molybdenum disulphide filled nylon* with superior wear and low frictional properties.

HIGHEST QUALITY NYLON

Polypenco Nylon Shapes are produced under rigid controls to provide you with materials of uniform toughness, density and dimensional stability.

OTHER STOCK SHAPES

In addition to nylon strip, Polypenco Shapes also include rod, tubular bar, tubing, and slab—all available for immediate delivery from a nation-wide distribution system... Fabrication service is available for your parts—engineered for the best in design, quality and tolerances. Write for latest data.

THE POLYMER CORPORATION OF PENNA.
Reading, Penna.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

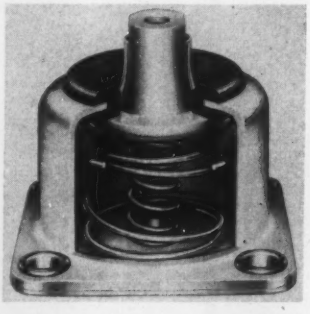
POLYPENCO

NYLON, TEFLON†, Q-200.5 (cross-linked polystyrene) and K-51 (chlorinated polyether)

*Patents applied for †Du Pont trademark

Circle 506 on page 19

New Parts



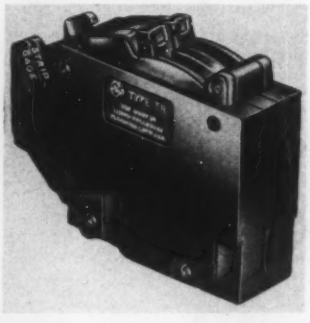
frequency. Units are dimensionally interchangeable with all MIL size 1 mounts. Independent horizontal damping suits mount for installation in the plane of center-of-gravity of mounted equipment. Mounts are available in seven load ranges from 0.25 to 10 lb per mount. Long and short-core units are available in each load range. Temperature range is − 85 to 250 F. **Barry Controls Inc.,** 822 Pleasant St., Watertown 72, Mass.

Circle 669 on page 19

Circuit Breaker

is twin plug-in unit

Up to twice the number of circuits normally possible in an average load center can be installed using Type TR twin plug-in circuit breaker. It combines two breakers in a single 1-in. case. Unit is available with ratings of 15 and 20 amp and is for use in protecting ac lighting and appliance branch



circuits. Handle extensions are available for combining two adjacent breakers for two-pole operation. Circuit breaker has interrupting rating of 5000 amp ac. **General Electric Co.,** Circuit Protective Devices Dept., Plainville, Conn.

Circle 670 on page 19

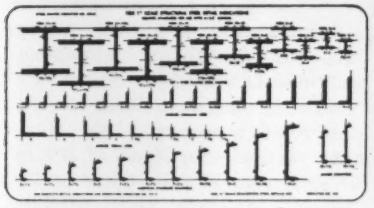
ENGINEERING DEPARTMENT

EQUIPMENT

Template Kit

for structural and reinforced steel symbols

Kit of five rigid-vinyl templates covers complete range of AISC and CRSI detailing profiles for structural and reinforced steel. Four templates cover steel beam, column and pipe shapes, channels, joists, angles, removable concrete forms, rivet-spacing scales and angle legs in ⅛, ¼, ½ and 1-in.



scales. Fifth template includes bar bends and hooks, bar size sections, concrete forms and stirrup bends. Each template is 5⅜ x 9⅞ in. in size. **A. Lawrence Karp,** P.O. Box 242, Greenwich, Conn.

Circle 671 on page 19

Bow Compasses

of aluminum and tempered tool steel

Universal-type bows are available in 7½, 5½ and 3½-in. sizes. They make circles with diameters of ⅛ to 14 in., 3/32 to 10 in., and 1/16 to 5 in., respectively. Bows are balanced, lightweight, and have nonglare finish. They are boxed with plastic tube holding extra leads, divider needle and spare parts. **Alvin & Co.,** 853 Palisado Ave., Windsor, Conn.

Circle 672 on page 19

Computing Device

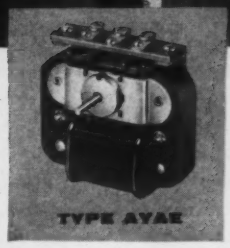
performs curve fittings and harmonic analyses

Model GEQ-450 Equameter is a manually operated computing de-

THE MARK OF QUALITY

BARBER COLMAN

Small Motors

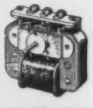


"We needed compact reversible motors to drive TV camera iris and focus mechanisms."

R. A. White, Mechanical Development Department
General Precision Laboratory Incorporated
Pleasantville, New York

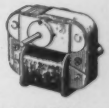
The GPL Remote Iris and Focus Television Camera shown above may be operated as far as 500 feet from control location — with complete remote control of lens optical focus and iris aperture. Vernier control of focus is provided regardless of lens focal length. For this camera, General Precision Laboratory selected two Barber-Colman AYAE reversible small motors . . . one drives the lens focus mechanism and the other drives the iris control. "Plus" features of this high-torque, fast-reversing Barber-Colman motor include low-inertia rotors for quick, positive start, rapid reverse . . . porous bronze bearings . . . hardened and ground stainless steel rotor shafts . . . rugged construction . . . long life. If you have a design problem involving small motors, let Barber-Colman Company engineers help you solve it with the exact motor for the job.

FREE HELPFUL DATA SERVICE on the complete line of Barber-Colman small motors which includes unidirectional, synchronous, and reversible motors up to 1/20 hp. With and without reduction gearing — open or enclosed types. Expert engineering service available. Write today, outline your problem, ask for free data sheets and Catalog F-4271, or see Sweet's Product Design File.


REVERSIBLE

SYNCHRONOUS

GEARED


UNIDIRECTIONAL

BARBER-COLMAN COMPANY

Dept. S, 1273 Rock Street, Rockford, Illinois

Small Motors • Automatic Controls • Industrial Instruments • Aircraft Controls
Electrical Components • Air Distribution Products • Overdoors and Operators
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Circle 507 on page 19

pip
SELF-LOCKING QUICK-RELEASE PINS

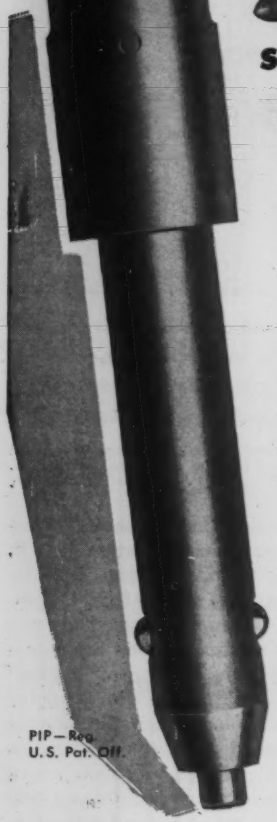
... MAKE AN OPEN AND SHUT CASE OF

Patented

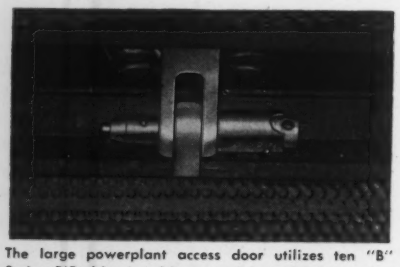
SPEEDING DOUGLAS F4D MAINTENANCE!

Fast removal and replacement of ventral access door is accomplished with "B" Series PIP pins. Through quick access, powerplant and systems maintenance time on the Navy's Douglas F4D aircraft is reduced!

This PIP pin application replaces other methods requiring nuts, bolts and cotter pins. Door installation and removal time is fast and simple as PIP pins are easily driven in or out of the fittings and automatically correct for hole misalignment caused by normal structural flexibility. *Safety and ease of use are increased!*



PIP—Reg. U. S. Pat. Off.



The large powerplant access door utilizes ten "B" Series PIP drive-in, drive-out pins in the hinge-type attachments as shown in photo. Locking is positive and automatic!

PIP pins are available in sizes to most bolt standards and in "T," "L," Ring and Button head styles. For complete information write for Bulletin ADI-5500.

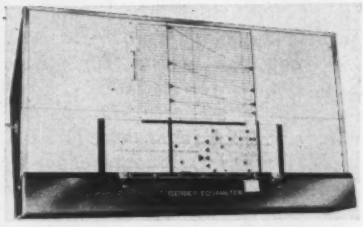
AVIATION DEVELOPMENTS INC.

210 SOUTH VICTORY BOULEVARD, BURBANK, CALIFORNIA

Burbank • Chicago • Denver • Fort Worth • Kansas City • London, England • New York • San Francisco • Seattle • Toronto, Canada • Wichita

Engineering Equipment

vice which performs harmonic analyses and curve fittings on plotted or recorded curves. It is capable of analyzing a curve in terms of Fourier Series, Power series, or orthogonal polynomials (least-square fits). It also produces the derivative or integral equations of a given curve. Unit can be operated by a person with little or no mathematical background. It is useful for convert-



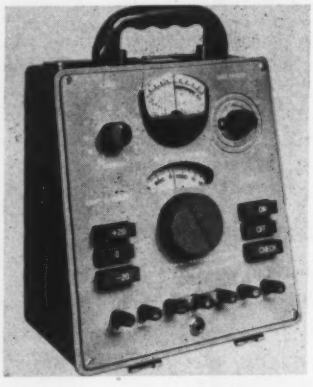
ing raw data to a form acceptable to large digital or analog computers, and for fitting polynomial equations to curves or test points. Completely self-contained, instrument reads a specimen with maximum vertical amplitude of 5.9 in. for cycle span of 9 in. horizontally. Longer curve can be subdivided into units of 9 in. or less. **Gerber Scientific Instrument Co.,** 162 State St., Hartford 3, Conn.

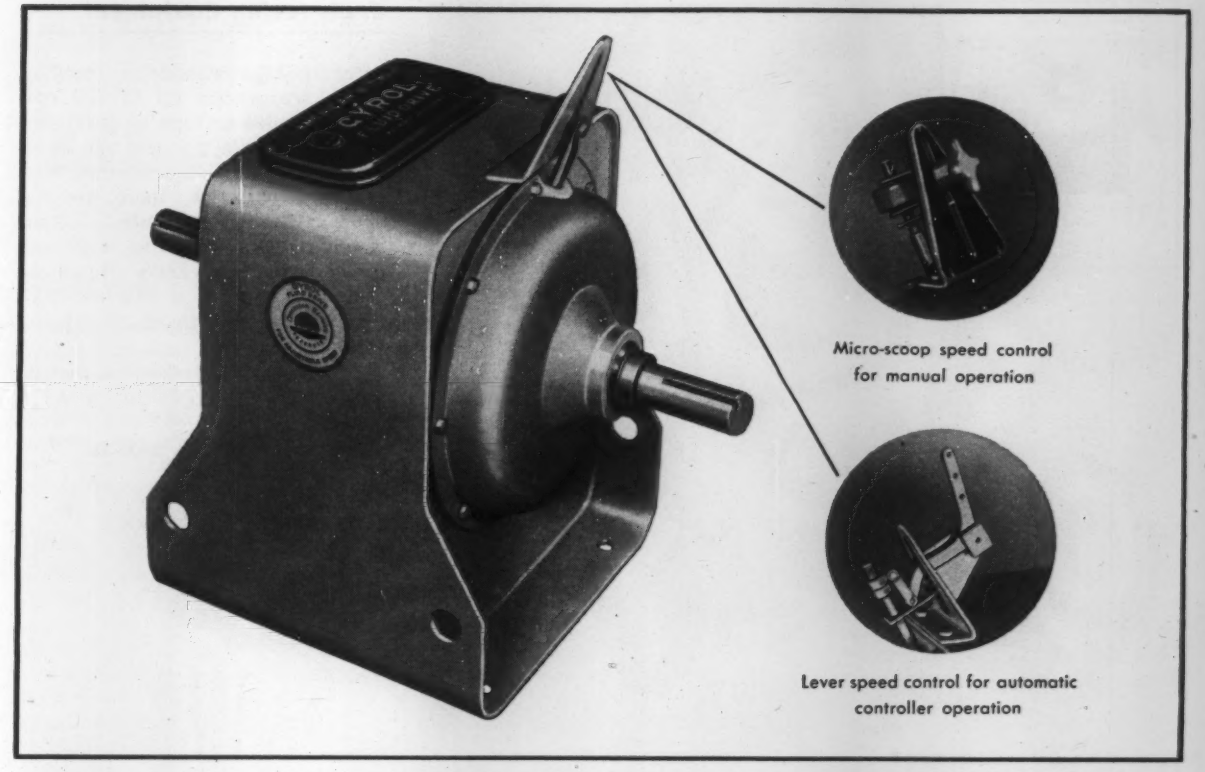
Circle 673 on page 19

Strain Indicator

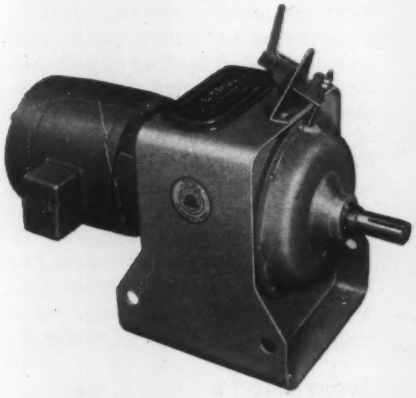
has improved accuracy

Type N strain indicator incorporates printed circuits and transistors to provide improved accuracy, life and range. There is no calibration error when instrument is used for direct readings with full external bridge. When indicator is used as a preamplifier





American Blower *Gýrol*® Fluid Drives now available in lower horsepower ranges!



Type VS, Class 2 Gýrol Fluid Drives for 1- to 25-hp applications. Also available with flange-mounted motor, as shown.

Adaptable to either automatic or manual control, American Blower Type VS, Class 2 Gýrol Fluid Drives come in a complete range of new smaller sizes—1 hp to 25 hp, speeds to 3600 rpm—to satisfy your every power-transmission need!

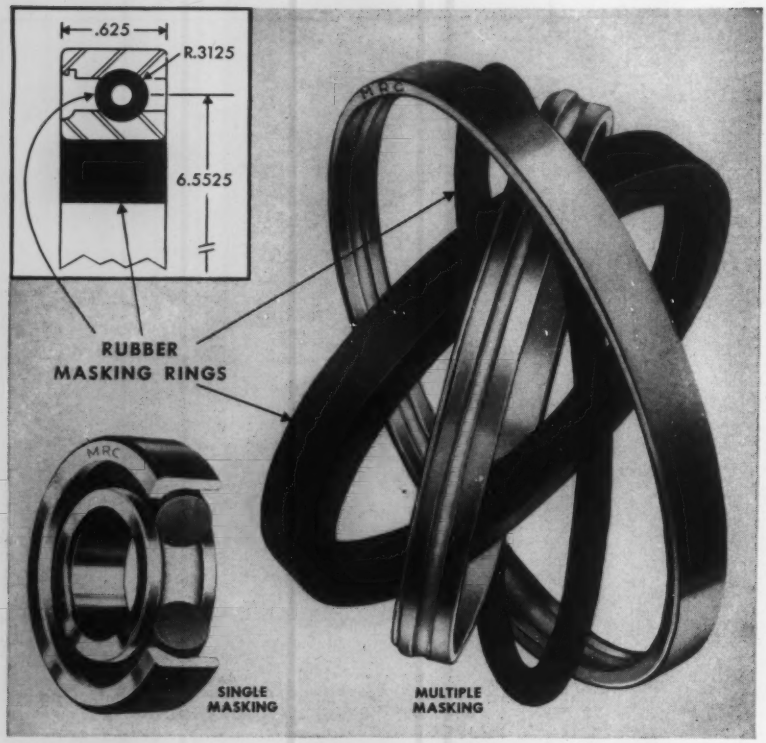
These compact, self-contained units offer an answer to many industrial-drive problems because of their important benefits: adjustable, stepless speed control; full reversibility; 5 to 1 speed range; no-load starting; protection against shock; quiet operation.

For full information on the complete line of Type VS, Class 2 Gýrol Fluid Drives, 1-800 hp—or other designs to 12,000 hp—contact our nearest branch office. Or write: American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

AMERICAN BLOWER

Division of AMERICAN-Standard

Circle 509 on page 19



Photos courtesy Marlin-Rockwell Corp., Jamestown, N. Y.

Rubber Rings Mask Bearings during Plating Process

Here's a new way to mask out plating on bearing race grooves without tedious hand-labor. Regardless of bearing size, rubber rings are fitted precisely into ball grooves and inner ring bore so that plating can't sneak under the rubber even in torturous electroplating baths. Clean division lines always result. Inner ring and outer ring are held together so both can be plated simultaneously. This saves one complete plating cycle. And, this fast assembly prepares bearings for plating in seconds—eliminates costly hand-painting with unreliable stop-off lacquer.

These rubber rings are the result of Marlin-Rockwell Corporation (Jamestown, New York) consulting Continental to solve an important masking problem. Creative engineering successfully developed these extruded and spliced, or molded rubber rings which increased production 2000%—20 times faster than hand-painting. What's more, the special rubber compound withstands repeated baths in blistering acids and caustics without affecting precise dimensions, elasticity or resilience.

This rubber ring technique is typical of the thinking and ingenuity behind rubber parts by Continental. It also represents the economy and better end results accomplished by consulting a rubber specialist *during the planning stage* of a product. If you need help like this, call or write Continental—rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

Circle 510 on page 19

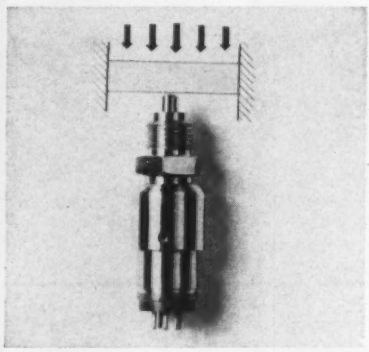
Engineering Equipment

with standard cathode-ray oscilloscope, frequencies up to 300 cps at amplitudes as high as 3500 microinch per in. can be observed without appreciable distortion. Except for batteries, there are no expendable components. Unit weighs 9 lb, requires no warm-up period. **Baldwin - Lima - Hamilton Corp.**, Electronics & Instrumentation Div., 42 Fourth St., Waltham, Mass.

Circle 674 on page 19

Force Pickups

measure forces to 2000 lb



Strain-gage force pickups measure forces in applications where deflection caused by force is limited to 0.00035-in. They are useful in measuring sudden forces applied to rigid physical structures. Either compression or tension forces can be measured, depending on how instrument is mounted. Units can also be used to test force-producing components, such as solenoids. Pickups are available in various ranges from 0 to 5 lb to 0 to 2000 lb. Excitation is 6, 12 or 15 v ac or dc. Temperature range is −65 to 350 F. **Dynamic Instrument Co. Inc.**, 28 Carleton St., Cambridge, Mass.

Circle 675 on page 19

Screw Selector

in slide-rule form

Visidex screw selector is a time-saving slide-rule device for engineers, designers and draftmen. It gives all essential dimensions and details required in selecting screws, bolts, nuts and rivets. **Visidex Co.**, 1019 N. Madison Ave., Hollywood, Calif.

Circle 676 on page 19

THE ENGINEER'S

Library

Recent Books

Engineering Electronics. *By John D. Ryder, Dean of Engineering, Michigan State University; 666 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 postpaid.*

This book provides a fundamental coverage of nonradio areas of electronics, particularly, areas of interest in instrumenation and computation. It includes electronics and operating principles relative to computers and servomechanisms without becoming an instruction book in operation or maintenance.

Emphasis throughout is on underlying principles and basic circuits applicable to various electronic devices and equipment. Treatment is quantitative, rather than descriptive or qualitative.

Recent advancements in semiconductors and transistors are included, particularly a fundamental development of the transistor equivalent circuit from four-terminal network theory. Two chapters cover fundamentals of electronic computation, both by analog and digital methods, as well as circuits applicable to both forms of computation. Not previously treated in such works is material on frequency response of amplifiers from both sinusoidal and pulse standpoints. Illustrative, worked exercises and problems are included in the text.

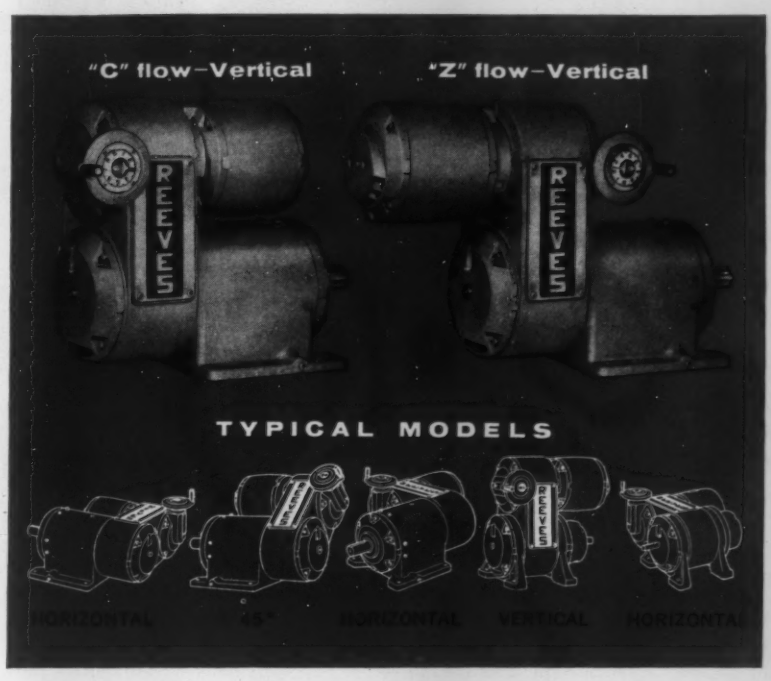
Elements of Instrumention: II, Temperature Transducers, PB 121296. *By K. S. Lion and W. L. Harries, Massachusetts Institute of Technology; 35 pages, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $1.00 per copy.*

This report describes various transducers for direct electrical

NEW **REEVES**®

*Sizes 200-300 Vari-Speed MOTODRIVES**

**200-300 Size, 1 through 5 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

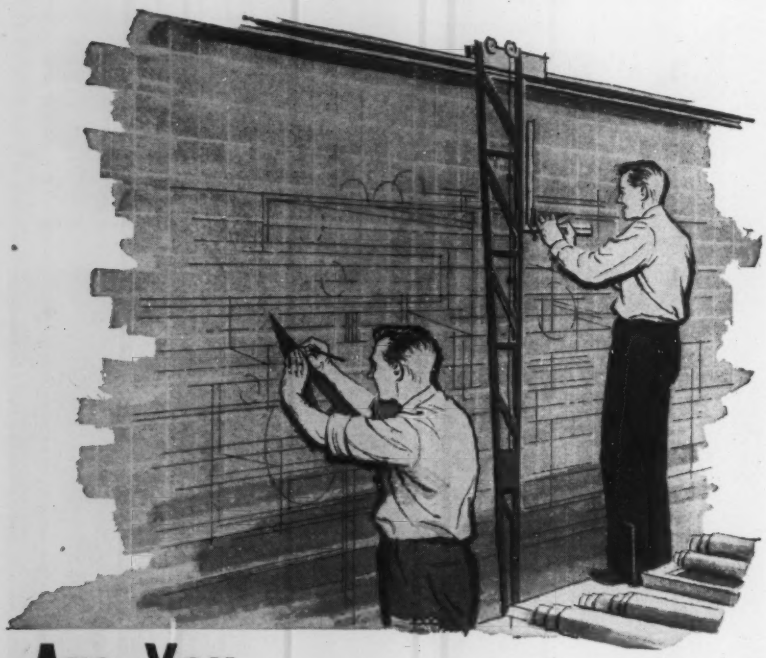
New increased capacity is built in the reducers—single, double or triple stages...new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Complete information on all phases of the versatile 200-300 sizes Vari-Speed Motodrives is given in new Catalog. Write for your free copy today—Dept. H32-M571.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana



Are You an Engineer's Engineer?

Then you will enjoy meeting the men at Pioneer. Here are gathered together the most versatile and competent staffs of product development and design engineers you can imagine.

They are real engineers' engineers. There is nothing in the world to them like getting their teeth into a product design and development, or improvement project.

As every engineer's engineer has to be, they are thoroughly practical. If you wish, they can help you right from the sketch or idea stage through all phases, including a complete set of manufacturing drawings. What's more, these drawings will guarantee the most economical production costs. They can help you with development, with styling for today or tomorrow, with engineering analysis, production methods and tools, on prototype building and testing, performance analysis and specifications.

Industry has called on them on over 264,000 jobs in the past 25 years. Working with engineering staffs like yours, they are trained to assemble ideas from their experiences in dozens of fields and apply them to the development of a better, more economical, more saleable, MORE PROFITABLE product in a still different field . . . yours!

You can write your own specs as to what you want them to do for you, and how. They'll be part of your team. They are a real engineer's engineers . . .

P. S.—Pioneer's Chief Engineer has some material he'll be glad to send you, giving more details on our services. Ask him for Bulletin PE-60

SINCE 1931 Pioneer ENGINEERING & MANUFACTURING CO., INC.
Telephone - TWinbrook 3-4500
19669 John R Street, Detroit 3, Michigan

INDUSTRIAL ENGINEERS, CONSULTANTS & DESIGNERS
BRANCH OFFICES IN DAYTON, OHIO, WASHINGTON, D. C. and TORONTO, ONT., CAN.

Library

measurement of temperatures. The transducers furnish an electrical signal which is a function of the temperature to which the element is exposed. Among instruments discussed are the resistance thermometer, which detects variations of 1/10,000 of one degree centigrade at room temperature, and the platinum resistance thermometer, which is the most accurate for temperature measurements. Others are the electrolytic transducer, ionized gas transducer, two inductive temperature transducers, thermoelectric transducers, and a noise thermometer for measurement over a wide temperature range.

Technical Descriptive Geometry. *By Leighton Wellman, Div. of Engineering Drawing, Worcester Polytechnic Institute; 628 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$5.75 postpaid.*

A second edition, this book provides a comprehensive and modern treatment of theory and practical applications of descriptive geometry. The auxiliary-view method is reduced to its simplest elements. There are no imaginary planes and projections. Consistent with practice, attention is concentrated on the object itself, and direction of sight for various views is emphasized. Complete analysis of important problems is followed by a summary which focuses attention on key ideas.

Air Conditioning. *By Willis R. Woolrich, Dean of Engineering, University of Texas; 384 pages, 6 by 9 in., clothbound; published by The Ronald Press Co., 15 East 26th St., New York 10, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

This book emphasizes fundamentals and provides complete introduction to all aspects of air conditioning, including heating, ventilation, air purification, and cooling.

It explains and analyzes traditional problems of heating. It also shows how psychrometric processes, radiant cooling, and available means of refrigeration are applied

Design "Low Cost" Into YOUR Equipment

GITS

World's Largest Selection of Low-Cost Lubricating Devices

LUBRIKIT . . . An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

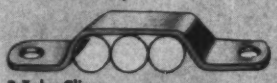
Special Introductory Price
Just **$14.95** F.O.B. Factory
Satisfaction or your money back

CLIPS FOR ATTACHING TUBING

When ordering, specify ¼", 3/16" or ⅜" tubes. Style TF.

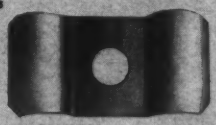
Single Clips

Double Clips

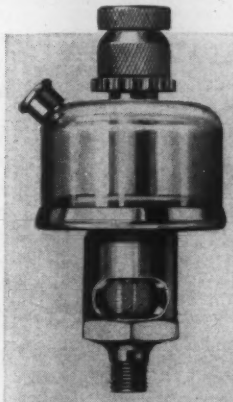


3-Tube Clips

4-Tube Clips

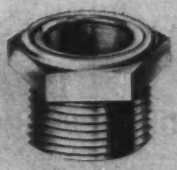


Double Clips — Wing Type



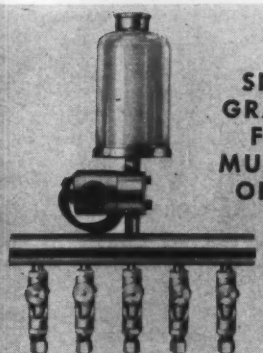
SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.



GEAR CASE GAUGES

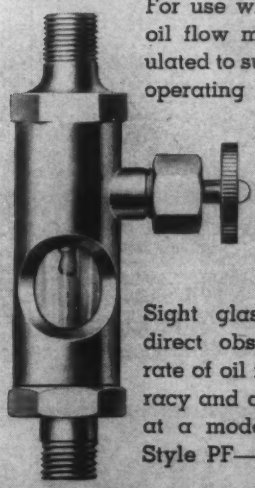
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (Illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

GITS BROS. MFG. CO.

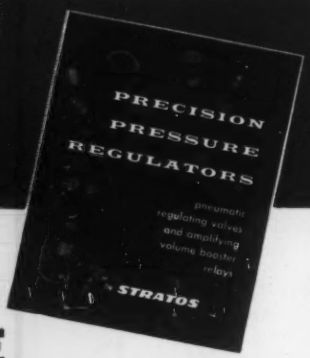
The Standard For Industry For Almost Half A Century

1868-C South Kilbourn Avenue
Chicago 23, Illinois

Clip this page for handy "rough reference"

Circle 513 on page 19

write for NEW
FREE
CATALOG



of precision
pneumatic
PRESSURE
REGULATORS

The facts you need on a complete range of pneumatic pressure regulating valves and volume boosters. Here is your guide to a series of pilot-operated and direct acting regulators—in pipe sizes from ¼ to ⅜ and ¾ NPT...in supply pressures up to 250 psi. Fact-filled pages spell out the full story: characteristics • pressure ranges, ratios • applications—for 16 different models including motor operated and lever set types.

Write today for the new KENDALL-GOVERNAIRE catalog.

STRATOS
INDUSTRIAL PRODUCTS BRANCH
Route 109, West Babylon, N. Y.
A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

Circle 514 on page 19

Design Guide to
"Adjustable-Speed Drives"

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

MACHINE DESIGN READER SERVICE
Penton Building
Cleveland 13, Ohio

Library

to the solution of problems.

The book stresses principles and application to design rather than quantitative and tabular data used in design procedure.

New Standards

ASTM Specifications for Steel Piping Materials. 445 *pages,* 6 *by* 9 *in., paperbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.;* $4.50 *per copy.*

This compilation of ASTM Standards contains all specifications for carbon-steel and alloy-steel pipe and tubing issued by ASTM through work of its Committee A-1 on Steel.

Five stainless-steel tubing specifications cover pipes for liquids, vapors and gases at normal and high temperatures, still tubes for refinery service, heat exchanger and condenser tubes, and boiler and superheater tubes. Also included are specifications for materials of castings, forgings, bolts and nuts as relateded to pipe for a variety of application conditions.

Government Publications

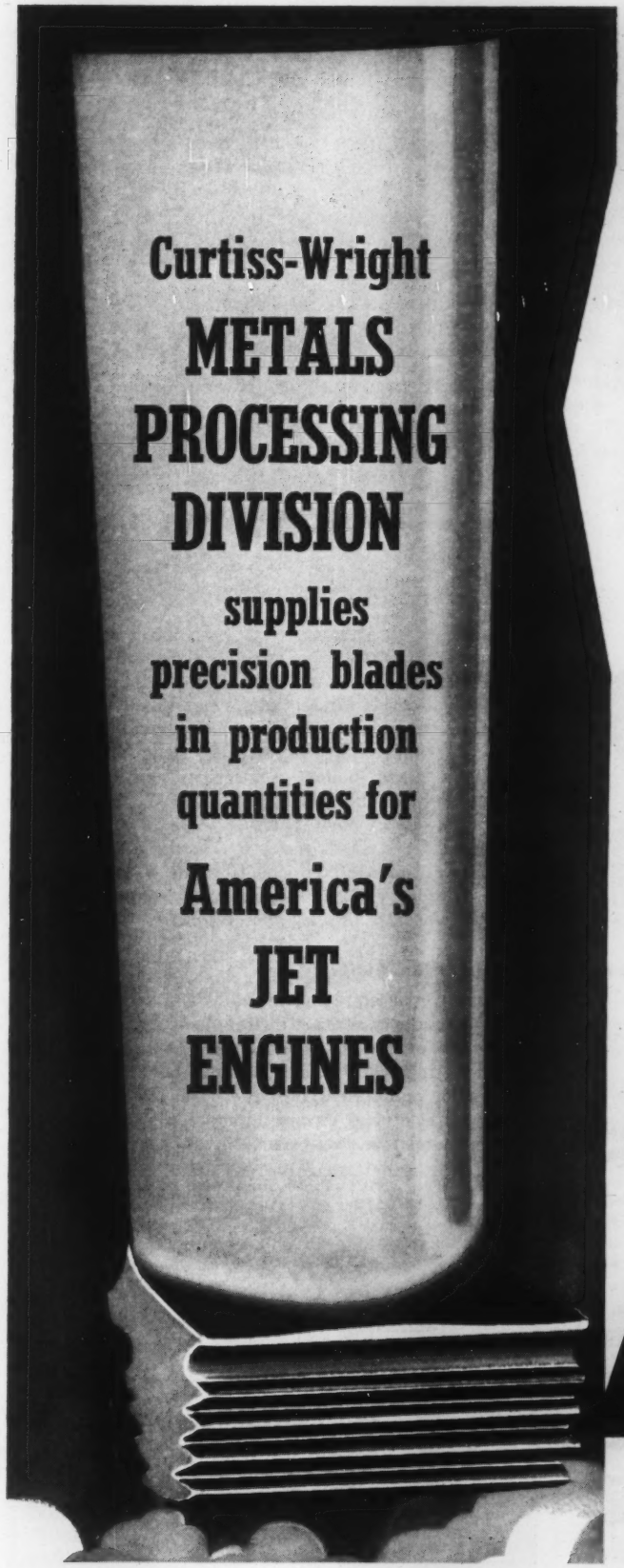
Forming Titanium and Titanium Alloys, Vol. 1, PB 121917. *By W. P. Achbach;* 248 *pages,* 8½ *by* 11 *in., paperbound; available from Office of Technical Services, U.S. Department of Commerce, Washington* 25, *D.C.;* $6.25 *per copy.*

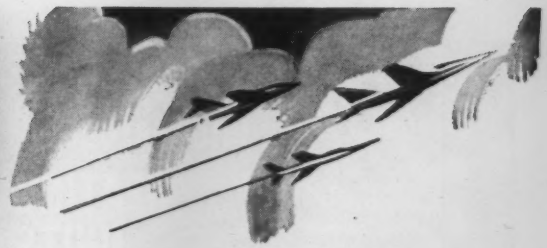
This book contains information on major methods of forming titanium sheet, compiled from a survey of the airframe industry.

Part 1, "General Considerations in the Forming of Titanium Sheet," contains accounts of processes preparatory to forming, of heating and stress relieving treatments, and of various formability tests.

Part 2, "Specific Considerations in Forming Titanium Sheet," contains detailed accounts of specific practices used for sheet materials. Also included are eight types of forming, refining and finishing of formed parts.

Part 3 contains a discussion of problems encountered in forming titanium.





FORGING

Air Superiority for National Defense

A complete prototype service for the design and production of jet engine blades is ready to work for you at the Metals Processing Division of Curtiss-Wright. One of the most experienced blade producers in the industry – now turning out thousands of blades daily – the Metals Processing Division can contribute importantly at any stage of your operation . . . from blueprint through prototype . . . from processing of pilot quantities to full volume production.

The Division's precision controlled production means more accurate development now . . . smoother production later. Coordinated facilities for casting, forging, grade rolling, machining and extrusion round out the picture. Write today for qualified engineering consultation, without obligation.

71 GRIDER STREET

METALS PROCESSING DIVISION

CURTISS-WRIGHT

CORPORATION • BUFFALO, N. Y.

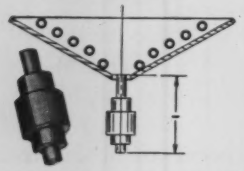
Circle 515 on page 19

The Lepel line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

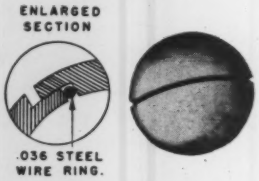
TYPICAL INDUCTION HEATING APPLICATIONS

TEMPERING FOR CUSTOM HEAT TREATING



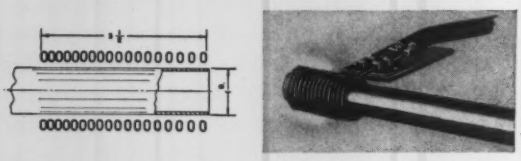
Selected areas of hardened steel parts may be tempered for fabrication or service requirements. Concentrator type coil permits high power density in restricted area thus minimizing heating time and permitting marked variation in properties in adjacent sections.

WIRE RING JOINS PLASTIC PARTS



High frequency induction heats wire ring which in turn heats plastic wall, providing sufficient plasticity to cause flow and bonding upon application of pressure. Metal to plastic seals are similarly performed.

ANNEALING ALUMINUM FURNITURE TUBING



Selective annealing of aluminum furniture tubing permits bending where required without loss of strength in adjacent portions of tube. Brass or steel tubing is also being selectively annealed.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

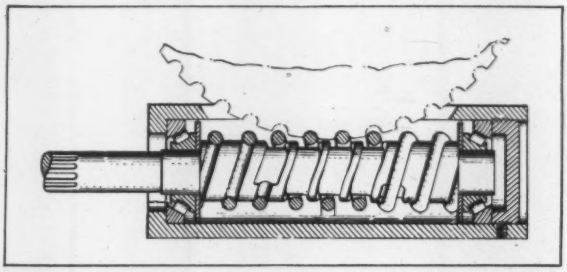
All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE-77, NEW YORK CITY, N. Y.

NOTEWORTHY Patents

Helical-Spring Worm

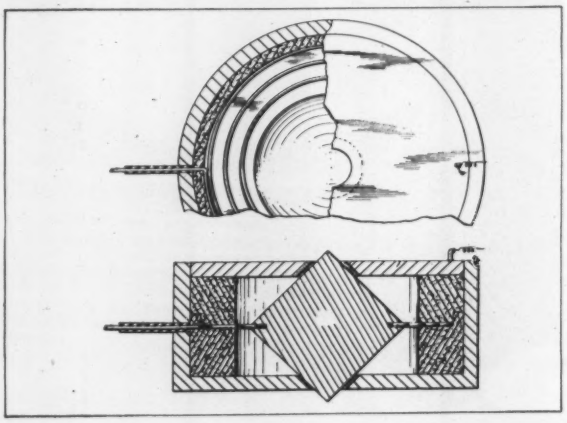
Overload torque is absorbed without permanent distortion of mating parts of a helical-spring worm-wheel assembly. Helical groove supporting the spring

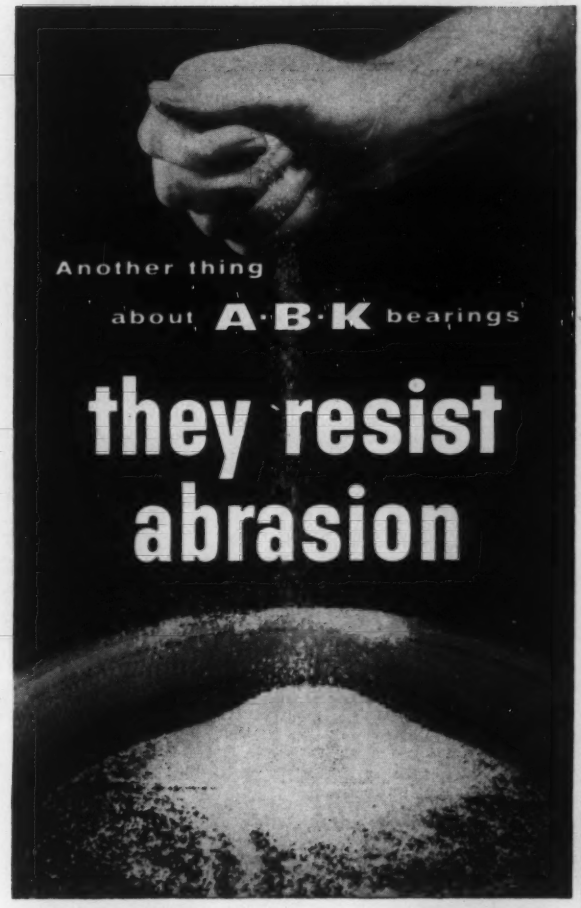


conforms closely to the spring cross section at the worm-shaft ends and widens and deepens at the shaft central section. Under abnormal load conditions, clearance between the spring and groove permits the spring to yield axially only to the point where it engages the rigid helical projections defined by the groove. When the overload is removed, the spring returns to its normal position. Resilient construction of the unit gives quiet operation, shock absorption and automatic compensation for wear of mating teeth. *Patent* 2,682,176 *assigned to General Electric Co. by Gilbert H. Fagley and Wayne E. Birchard.*

Acceleration Switch

Impact or acceleration provides the actuating force for a momentary-contact switch designed for missiles, detonators or similar applications. Comprising a case of conducting material and a double-cone inertia member spring mounted within the case, the switch completes an electrical circuit (impact member to case) whenever relative movement of the two elements oc-





A·B·K — the bearing material of 1001 uses

Now machine design can be simplified. Bearing problems caused by exposure to abrasive materials once were impossible to overcome. But now it's easy. Merely specify A-B-K bearing material.

The unique properties of A-B-K Laminated Phenolic Bearings have helped engineers in widely divergent fields solve their toughest bearing problems.

A-B-K bearing material not only resists abrasion . . . it can be formed or machined to intricate shapes. It can be bonded to metal. It can be lubricated with either oil or water. And, for certain uses, it will outlast metal ten to one.

If your bearing problem involves abrasion, impact, noise, strain or stress, friction, heat, chemical action or strength . . . our engineers invite your request for specific recommendations. Write today.

PROVED PROPERTIES

- Won't peen out
- High strength/weight ratio
- Resists acid, alkali, heat, abrasion
- High compression strength
- Perfect weathering
- Good machining
- Dimensional stability
- Outwears metal
- Water or oil lubricated

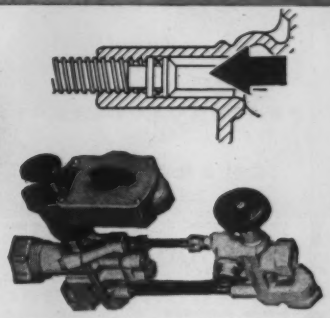
AMERICAN Brake Shoe COMPANY — American Brakeblok Division, DETROIT 9, MICHIGAN

Circle 517 on page 19

problem: *find a low-friction seal that positively seals at extremely low pressures*

new answer: *minnesota rubber's money-saving new*

evidence:



THE LINDSAY COMPANY, world's largest manufacturer of automatic home water softeners, uses three QUAD RINGS in its newest valve. Lindsay tested O-rings in the valve, but O-rings leaked at very low pressures. Then Lindsay tested QUAD RINGS, a revolutionary new seal originated and manufactured by Minnesota Rubber. QUAD RINGS sealed perfectly no matter how low the pressure. The Lindsay Company also found that it could open some of the tolerances on the valve parts—and save money—because QUAD RINGS give such a good seal with low friction.

QUAD RINGS are injection molded. Denser, tougher. 4-lip action even seals at less than 1 psi! Only 60-100 micro-inch groove finish needed. No parting line on sealing surface. Eliminates "spiral twist".

free samples and data:

Free samples of QUAD RINGS are available with a descriptive brochure of technical information and installation data.

QUAD RING is a Minnesota Rubber and Gasket Company trademark.

minnesota rubber & gasket company

Originators of modern rubber injection molding

Dept. 805, 3630 Wooddale Ave.
Minneapolis 16, Minnesota Phone WEst 9-6781

Circle 518 on page 19

"MONOBALL" Self-Aligning Bearings

PATENTED U.S.A.
All World Rights Reserved

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Alloy Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-57

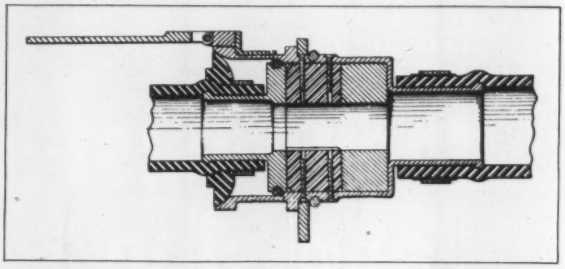
SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Noteworthy Patents

curs. *Patent 2,793,260 assigned to Olin Mathieson Chemical Corp. by Stanley J. Ciosek.*

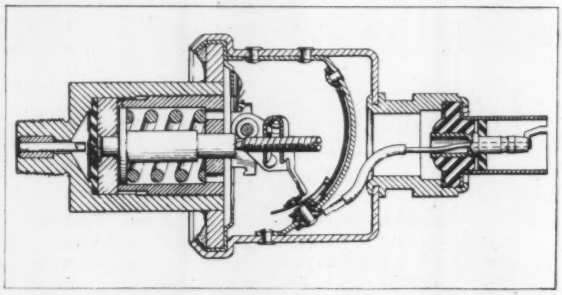
Magnetic Hose Coupling

Intended for use in low-pressure applications, a magnetic hose coupling provides protection against accidental disconnection, yet can be simply and positively



engaged. For connection, hose-end fitting, incorporating a "keeper" face, is inserted only a short distance into the body member. Permanent magnet in the body member then draws the keeper firmly against the magnet face. Should the keeper become accidentally separated a short distance from the magnet, the magnet immediately re-engages the coupling. *Patent 2,793,057 assigned to Douglas Aircraft Co. by Harry L. McGugin.*

High-Pressure Transducer

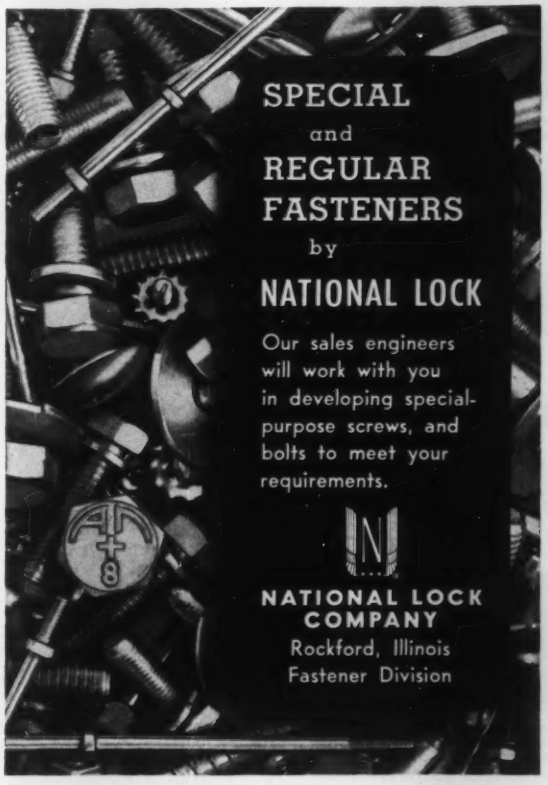


Positive sealing and rapid response are characteristics of a high-pressure transducer that combines diaphragm and piston-type sensing elements. Movement of the flexible diaphragm, which is positioned at the transducer pressure port (left) translates the piston against the compression spring. An output signal proportional to the applied pressure is developed when the contact arm of the variable-resistance element is pivoted by axial motion of the piston. Because of the relatively small diameter of the piston. the gage is particularly adapted for measurement of very high pressures. A typical unit allows 1/16-in. of piston movement for every 3000 lb of fluid pressure. *Patent 2,790,043 assigned to General Motors Corp. by Bertil H. Clason.*

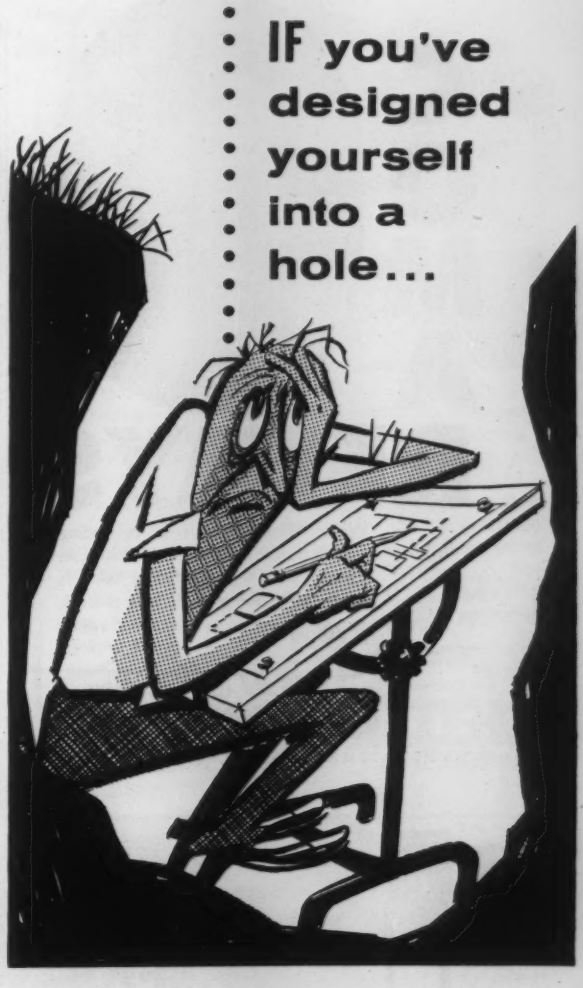
Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

THE TREND IN DRAFTING ROOMS THROUGHOUT THE WORLD IS TOWARD IMPERIAL, THE WORLD'S FINEST TRACING CLOTH

Circle 520 on page 19



Circle 522 on page 19

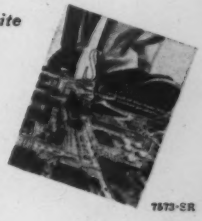


PERHAPS EXTREME HIGH AND LOW TEMPERATURE SILICONE PARTS BY STALWART WILL GET YOU OUT

The unusual qualities of silicone rubber compounds offer opportunities for simpler, more compact designs . . . smaller, lighter units that require less costly material and labor. Stalwart-engineered silicone rubber parts can be used in a wide range of applications involving temperature extremes from —130° to +600° F. with virtually no change in their physical, chemical and dielectric properties.

Stalwart's engineers and modern production facilities are prepared to produce an unlimited variety of precision molded, extruded, automatic and hand cut parts to customer specifications. Why not write us today about your specific problem.

For further information write for Bulletin 56-SR-3



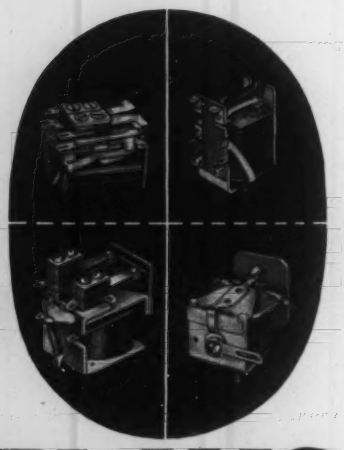
STALWART RUBBER COMPANY

Manufacturing plants in Bedford, Ohio and Jasper, Georgia. Main offices at 180 Northfield Road, Bedford, Ohio

7573-SR

Circle 521 on page 19

COMAR RELAYS



QUALITY ENGINEERED FOR DEPENDABLE OPERATION

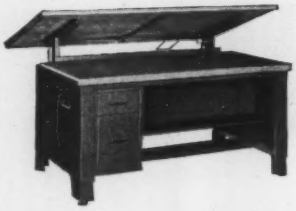
Comar relays are preferred by leading manufacturers everywhere. Highest quality, precision engineered, they help improve the performance of your product. Inquiries invited.

Comar ELECTRIC COMPANY
3349 ADDISON ST., CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

Circle 523 on page 19

MAYLINE



Dependable Drafting Room Furniture

MAYLINE MAY-O-MATIC TABLE

Mayline drafting room furniture is known for dependable and satisfactory service.

Have your local dealer give you all the details. See him today.

METAL PLAN FILE

STEEL 4-POST TABLE

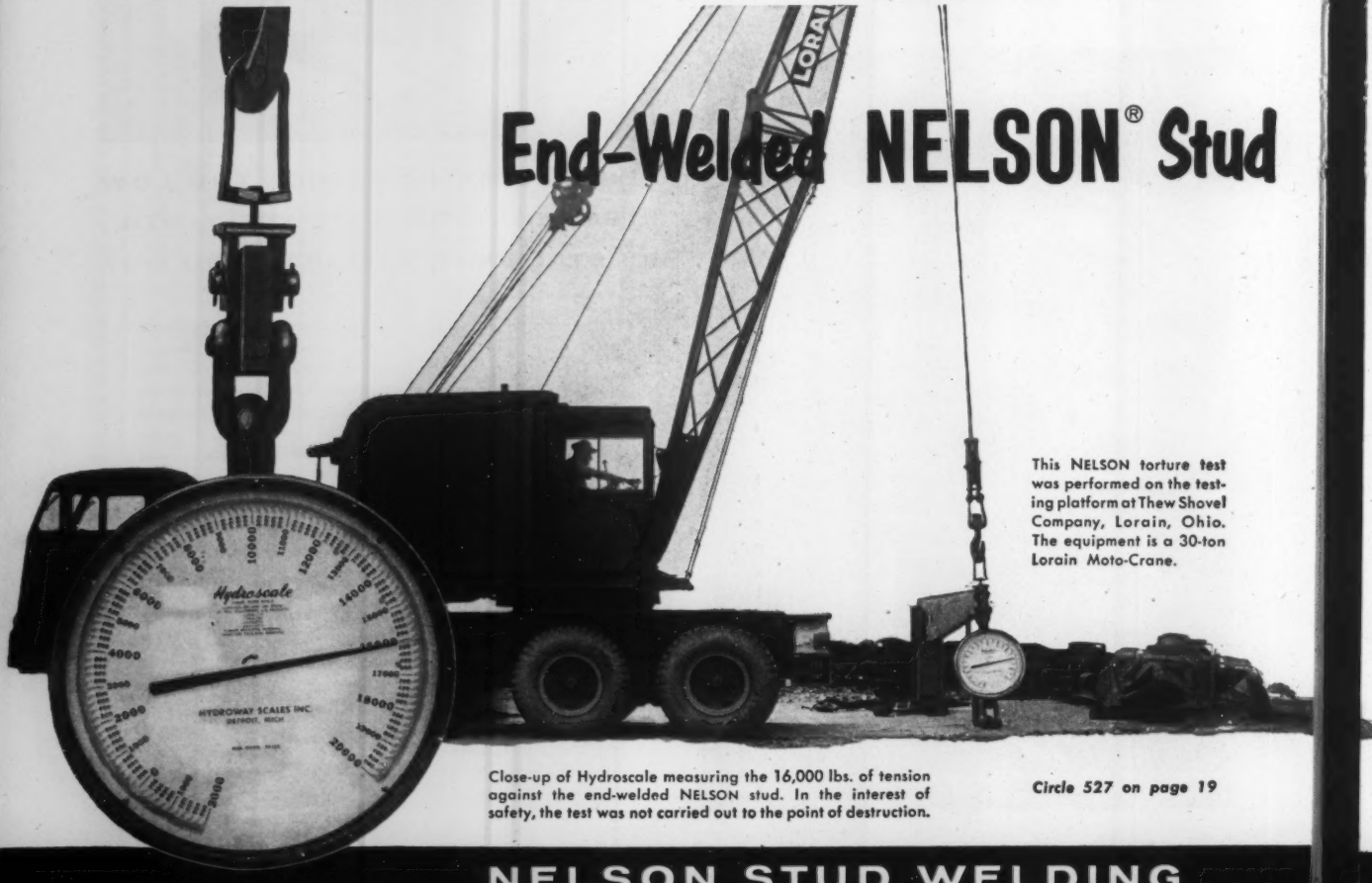
MAYLINE CO.

601 No. Commerce St.
Sheboygan, Wisconsin

MAYLINE

Circle 524 on page 19

End-Welded NELSON® Stud



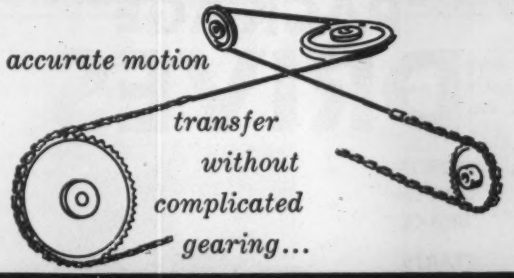
This NELSON torture test was performed on the testing platform at Thew Shovel Company, Lorain, Ohio. The equipment is a 30-ton Lorain Moto-Crane.

Close-up of Hydroscale measuring the 16,000 lbs. of tension against the end-welded NELSON stud. In the interest of safety, the test was not carried out to the point of destruction.

Circle 527 on page 19

NELSON STUD WELDING . . .

MORE DESIGN FREEDOM



SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

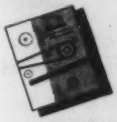
Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

123 E. Montecito Avenue,
Sierra Madre, California

Sierra ENGINEERING CO.

T. M. REG.

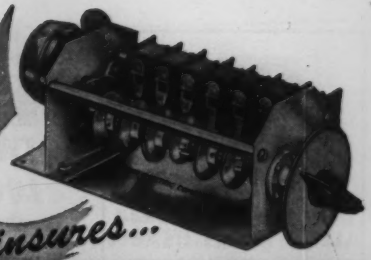
NEW CATALOG



Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

Circle 525 on page 19

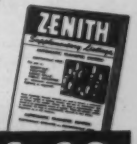
ZENITH Multi-Circuit CYCLE TIMER *insures...*



long-lasting accuracy . . . trouble-free performance in timing, mixing, compounding, processing and similar operations!

Sound, practical design, quality components and precision-controlled assembly insure the long-lasting dependability of ZENITH Multi-Circuit Timers. They are specified as standard components in countless commercial and industrial applications, as well as laboratory equipment and home appliances.

Can be supplied in practically any time cycle and with any number of switches. Available without synchronous motor for elevator control, limit switch, etc.



IMMEDIATE DELIVERY IN ANY QUANTITY...
Request bulletin.

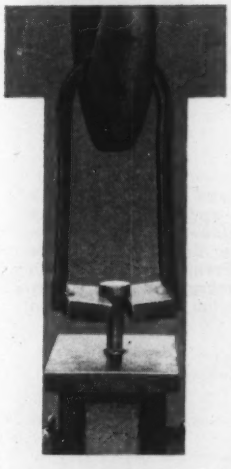
See classified telephone directory for name of local distributor

ZENITH ELECTRIC CO.

149 W. WALTON ST. • CHICAGO 10, ILL.

Circle 526 on page 19

Resists 8-Ton Load!



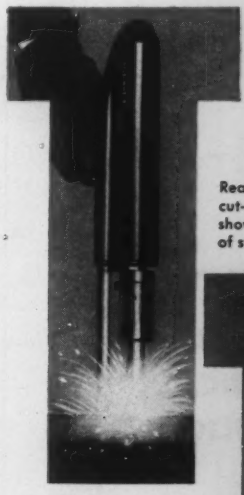
Close-up of stirrup used to complete the linkage between test stud and the crane cable hook. Photo was taken while stud was under full 16,000-lb. load. Bent stirrup indicates force of this grueling test.

• Nelson Engineers tested a ⅝" diameter standard headed stud to determine the strength of the weld.

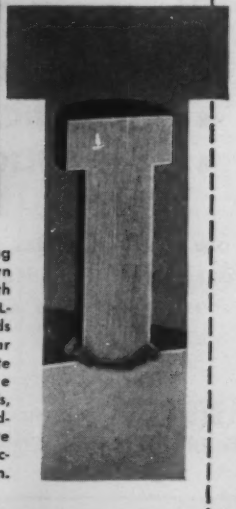
These photographs attest to the amazing tensile strength of a NELSON end-welded stud. Torsion and shear strength are equally amazing.

Holding power like this suggests that it pays to stop before drilling a hole and consider the NELWELD® method of fastening...the system that also saves time, eliminates flanges and bosses and makes "hole engineering" unnecessary.

The manual offered in the coupon goes into detail on design and applications, and recommended torque and tensile loadings of studs for normal applications.



Reason for strength... cut-a-way view of stud shows complete fusion of stud and base plate.



The headed stud being used in this test is shown being stud welded with the portable NS-9 NELWELD Gun. These studs are often used as shear connectors on concrete and steel composite bridges. Threaded studs, and a multitude of standard types and sizes are available for manufacturing and construction.

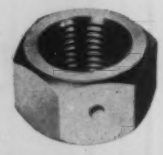
***NEW* NELWELD DESIGN MANUAL**

yours for the asking. Write your name, company, address in this space, and send to NELSON.

Fasten It Better at Less Cost with

Division of Gregory Industries, Inc., Lorain, Ohio

NELWELD



THE **M·F** *TWO-WAY LOCK NUT*

DOUBLE CHAMFERED ALL-METAL RE-USABLE

Starts from either end—locks in body of nut, not at the crown.

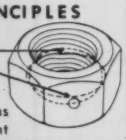
FOR FAST, AUTOMATED APPLICATION, WITHOUT SELECTIVE DEVICES

MORE LOCKING POWER WHEN BOLT ENDS MUST BE FLUSH WITH NUT

Because the locking device is in the body of the nut, not at the ends, the lock is farther from the end of the bolt—a more positive lock even when *all threads are not used!*

TWO LOCKING PRINCIPLES

TWO POINTS OF LOCK



Ovalized as well as deflected at point of lock. Opposing center pressure points give 180° spring.

OFF-THE-SHELF SIZES

SIZE	THREADS PER INCH		FULL THICKNESS WIDTH ACROSS	FULL THICKNESS THICKNESS
#10 *	32	24	7/16	7/32
1/4	28	20	7/16	7/32
5/16	24	18	1/2	17/64
3/8	24	16	9/16	21/64
7/16	20	14	5/8	3/8
7/16	20	14	11/16	3/8
1/2 †	20	13	3/4	7/16
9/16	18	12	7/8	31/64
5/8	18	11	15/16	35/64
3/4	16	10	1 1/8	41/64

* 1/4" Blank † Available Jam Thickness in 1/2" and Over.

MAC LEAN-FOGG

Lock Nut Company 5535 N. Wolcott Street, Chicago 40, Ill.

Circle 528 on page 19

"PACKAGE" DRIVES

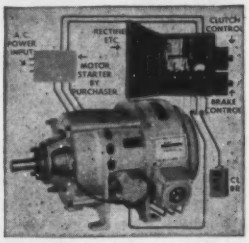
MOTOR CLUTCH BRAKE

STARTS, STOPS AT CONTROLLED RATES

AUTOMATIC CYCLING FOR:

- CONVEYORS
- PUNCH PRESS
- SHEARS
- HOISTS
- INDEXING

. . . many applications in automation



ERICSSON-MERRITT DRIVE WITH AUTOMATIC STOP-GO CONTROLS

Compactly built around rugged Fairbanks-Morse axial air-gap constant speed motor and nationally known time tested magnetic clutch and brake components. Can be operated up to 30 cycles per minute. Available in 1½ through 15 HP units, all with constant torque and at standard motor speeds between 600 and 1800 R.P.M. 15 HP unit is 18" in dia. by 25" long. May be ordered as standard units or complete with special control cabinet for automatic cycling. Write for details today.

ERICSSON-MERRITT, Inc.

504 PINE STREET • LOCKPORT, N. Y.

Circle 529 on page 19

Design Guide to

"Adjustable-Speed Drives"

- **ELECTRICAL**
- **MECHANICAL**
- **HYDRAULIC**

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

$2.00 per copy

MACHINE DESIGN READER SERVICE

Penton Building Cleveland 13, Ohio

ENGINEERS

AVAILABLE OR WANTED

WANTED: SALES ENGINEER for sales and engineering work in hydraulic and pneumatic leather and rubber packing installations. Some technical and engineering aptitude desirable coupled with good sales sense. Relocation may be necessary after a year of training. Promising future with solid company. Let us have your background and salary area. Box 919 MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Development Engineer to supervise the development and design of a wide variety of Power Transmission Devices. Excellent opportunity with reputabe manufacturer now engaged in this business. Location—Middle Atlantic area. Give full particulars, education and experience. Address Box 920, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Advertising Index

Aeroquip Corporation 148, 149
Ajax Flexible Coupling Co., Inc. 66
Allegheny Ludlum Steel Corporation 135
Allen Manufacturing Co. 117
American Blower Division of American Standard 169
American Brakeblok Division, American Brake Shoe Co. 177
American Brake Shoe Co., American Brakeblok Division 177
American Brake Shoe Co., National Bearing Division 152
American Brass Co., The, American Metal Hose Division 4
American-Standard, American Blower Division 169
American Metal Hose Division, The American Brass Co. 4
American Welding & Manufacturing Co., The 115
Ampco Metal, Inc. 60
Armstrong Cork Co., Industrial Division 51
Arwood Precision Casting Corporation 143
Automotive Gear Division, Eaton Manufacturing Co. 16
Aviation Developments, Inc. 168

Barber-Colman Co. 167
Bethlehem Steel Co 147
Bishop, J., & Co., Platinum Works, Stainless Steel Products Division 122
Blood Brothers Machine Division, Rockwell Spring and Axle Co. 129
Bound Brook Oil-less Bearing Co. 9
Brad Foote Gear Works, Inc. 35
Briggs & Stratton Corporation 59
Bruning, Charles, Co., Inc. 11

Carpenter Steel Co., The, Alloy Tube Division 44
Carter Controls, Inc. 125
Cincinnati Gear Co., The 148
Cleveland Cap Screw Co., The 165
Cleveland Worm and Gear Co., The ..... Inside Back Cover
Columbia-Geneva Steel Division, United States Steel Corporation 64, 65
Comar Electric Co. 180
Continental Rubber Works 170
Cramer Controls Corporation 46
Crucible Steel Company of America 47
Curtiss-Wright Corporation, Metals Processing Division 175
Cutler-Hammer, Inc. ..... Back Cover

Dodge Manufacturing Corporation 40, 41
Duff-Norton Co. 138
Du Pont, E. I., de Nemours & Co., Inc. 53
Durakool, Inc. 130

Eastman Manufacturing Co. 30
Eaton Manufacturing Co., Automotive Gear Division 16
Eaton Manufacturing Co., Foundry Division 68
Elastic Stop Nut Corporation of America 158
Electric Steel Foundry Co. 144
Electric Wheel Co., Division of The Firestone Tire & Rubber Co. 28
Emerson Electric Manufacturing Co., The 52
Equipment Engineering Co. 130
Ericsson-Merritt, Inc. 182

Fairbanks, Morse & Co., Magneto Division 111
Fairchild Engine and Airplane Corporation, Stratos Industrial Products Branch 174
Falk Corporation, The 139
Farrel-Birmingham Co., Inc. 151
Fellows Gear Shaper Co., The 43
Felters Co., The 142
Firestone Tire & Rubber Co., The, Electric Wheel Co. Division 28
Foote Bros. Gear and Machine Corporation .. 154
Foundry Division, Eaton Manufacturing Co. ... 68
Fuller Manufacturing Co., Transmission Division 159

Gast Manufacturing Corporation 145
General Aniline & Film Corporation, Ozalid Division 38
Gits Bros. Manufacturing Co. 173
Goodrich, B. F., Co., The, Aviation Products Division 45
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 127
Goodyear Tire & Rubber Co., The, Industrial Products Division 2
Gregory Industries, Inc., Nelson Stud Welding Division 180, 181

Hamilton Foundry and Machine Co., The 155
Hannifin Corporation 39
Hansen Manufacturing Co., Inc. 124
Haynes Stellite Co., Division of Union Carbide Corporation 27
Heli-Coil Corporation 156
Houdaille Industries, Inc., Manzel Division ... 134
Howard Industries, Inc. 133

Imperial Pencil Tracing Cloth Co. 179
Ingersoll-Rand 126
International Research and Development Corporation 146

Jack & Heintz, Inc. 67

Kennametal, Inc. 150

Lepel High Frequency Laboratories, Inc. 176
Linde Co., A Division of Union Carbide Corporation 185
Link-Belt Co. 61
Lord Manufacturing Co. 141
Lovejoy Flexible Coupling Co. 31

McGill Manufacturing Co., Inc. 119

MacLean-Fogg Lock Nut Co. 182
Manzel, A Division of Houdaille Industries, Inc. 134
Maurey Manufacturing Corporation 136
Mayline Co. 180
Metals & Controls Corporation, Spencer Thermostat Division 161
Minnesota Rubber & Gasket Co. 177
Morganite, Inc. 34

National Bearing Division, American Brake Shoe Co. 152
National Lock Co. 179
National Supply Co., The, Industrial Products Division 140
Nelson Stud Welding, Division of Gregory Industries, Inc. 180, 181
New York Belting & Packing Co. 121
Norgren, C. A., Co. 21

Ohio Gear Co., The 163
Oilgear Co., The 7
Ozalid, A Division of General Aniline & Film Corporation 38

MACHINE DESIGN

Penton Building Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

Mary L. Callahan
Advertising Service Manager

Richard A. Templeton
Research and Circulation Manager

David C. Kiefer
Marketing Director

Robert E. Lessing
Production Manager

District Offices

New York 17 .....60 East 42nd St.
Russell H. Smith, James A. Stangarone
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
Alan C. Bugbee
Oldfield 8-4764

Dresher, (Philadelphia) Pa. ..1335 Harris Road
Chandler C. Henley
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
Jack W. Walton
Don J. Billings
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
Charles F. Reiner
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
Howard H. Dreyer, Robert Z. Chew
Donald A. Ivins
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. Fuller
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....1106 Pine Valley Road
Fred J. Allen
Griffin 7854

London, S.W.1 .....2 Caxton St., Westminster

Published by

THE PENTON PUBLISHING COMPANY

G. O. HAYS .....President
R. C. JAENKE .....Executive Vice President
F. G. STEINEBACH ... Vice President and Secy.
F. O. RICE .....Vice President
J. P. LIPKA..Treasurer and Assistant Secretary

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

Machine Design is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyright 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NEP

26

Complete reprints of major articles now available from MACHINE DESIGN

USE THIS FORM TO ORDER YOUR COPIES TODAY!

Number Copies		Price Per Copy
_____	DIRECTORY OF MATERIALS—18th Edition	$1.00
_____	PRODUCTION CHARACTERISTICS OF ENGINEERING METALS	1.00
_____	DESIGN MANUAL ON ADHESIVES	1.00
_____	NONMETALLIC GASKETS	1.00
_____	ADJUSTABLE SPEED DRIVES	2.00
_____	ADJUSTABLE-SPEED ELECTRIC-MOTOR DRIVES	1.00
_____	MECHANICAL ADJUSTABLE-SPEED DRIVES	1.00
_____	SPEED REDUCERS AND GEARMOTORS	1.00
_____	INTERNAL COMBUSTION ENGINES	1.00
_____	WHY MACHINE PARTS FAIL	1.00
_____	STRESS ANALYSIS IN DESIGN	1.00
_____	DIMENSION CONTROL IN DESIGN	1.00
_____	HYDRAULIC SERVO FUNDAMENTALS Vol. I	1.00
_____	PRECISION GEARING	1.00
_____	QUALITY CONTROL METHODS	1.00
_____	DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY	1.00
_____	MULTIPLE CIRCUIT SWITCHES	1.00
_____	ELECTRICAL CONNECTORS	1.00
_____	TRANSACTIONS OF THE FIRST CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS OF THE SECOND CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS ON THE THIRD CONFERENCE ON MECHANISMS	1.00
_____	MECHANISMS FOR INTERMITTENT MOTION	1.00
_____	POLYDYNE CAM DESIGN	1.00
_____	EVALUATING ENGINEERS	1.00
_____	ENGINEERING MANAGEMENT	2.00
_____	MEN AND MACHINES	1.00

MACHINE DESIGN
Reader Service
Penton Building
Cleveland 13, Ohio

TOTAL COPIES _____

TOTAL ORDER $_____

☐ Remittance Enclosed ☐ Please Bill Me

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE_____ STATE_____

(Add 3% to orders in Ohio to cover State Sales Tax)

Advertising Index

Parker White Metal Co. 157
Pioneer Engineering & Manufacturing Co., Inc. 172
Polymer Corporation of Pennsylvania, The ... 166
Post, Frederick, Co. 15
Pratt & Whitney Co., Inc. 122, 123

Redmond Co., The 56, 57
Reeves Pulley Co., Division of Reliance Electric and Engineering Co. 171
Reliance Electric and Engineering Co., Reeves Pulley Co. Division 171
Reuland Electric Co. 63
Robbins & Myers, Inc. 137
Rockwell Spring and Axle Co., Blood Brothers Machine Division 129
Rogers Corporation 131
Ross Operating Valve Co. 1

Sierra Engineering Co. 181
South Chester Corporation, Southco Division .. 42
Southco Division, South Chester Corporation .. 42
Southwest Products Co. 178
Spencer Thermostat Division, Metals & Controls Corporation 161
Standard Pressed Steel Co., Flexloc Locknut Division 153
Standard Pressed Steel Co., Unbrako Socket Screw Division 50
Stalwart Rubber Co. 179
Statham Laboratories 25
Stearns Electric Corporation 160
Stow Manufacturing Co. 162
Stratos Industrial Products Branch, A Division of Fairchild Engine and Airplane Corporation 174
Superior Carbon Products, Inc. 132
Sylvania Electric Products Inc., Parts Division 29
Synthane Corporation 58

Tennessee Coal & Iron Division, United States Steel Corporation 64, 65
Timken Roller Bearing Co., The, Steel and Tube Division 23
Torrington Co., The 13
Torrington Manufacturing Co., The 62
Tuthill Pump Co. 69
Twin Disc Clutch Co., Hydraulic Division 70

Union Carbide Corporation, Linde Co. 185
Union Carbide Corporation, Haynes Stellite Division 27
Unitcast Corporation 36
United States Graphite Co., The, Division of The Wickes Corporation 32, 33
United States Steel Corporation, Subsidiaries 64, 65
United States Steel Export Co. 64, 65
United States Steel Supply Division, United States Steel Corporation 64, 65

Wagner Electric Corporation 54
Ward Leonard Electric Co., The 113
Warren Pumps, Inc. 164
Weatherhead Co., The 24
Westinghouse Electric Corporation 48, 49
White, S. S., Industrial Division ..... Inside Front Cover
Whitney Chain Co. 55
Wichita Clutch Co., Inc. 37
Wickes Corporation, The, The United States Graphite Co. Division 32, 33

Zenith Electric Co. 181

Engineers Available or Wanted 182

HELIARC Welding
finds satellite jobs are right in its orbit

Welding together sections for an earth satellite, under the most exacting specifications, may not be your particular problem. But if welding light-gage, hard-to-weld metals is slowing up your production—LINDE's HELIARC Inert Gas Shielded Arc Welding, using LINDE Argon as a shielding gas, may be just what you've been looking for.

HELIARC Welding is LINDE's method for high-speed fusion of commercial metals, automatically, or manually in all positions. LINDE Argon, guaranteed 99.99% pure, protects the weld. It is readily available, in cylinders or in bulk, from convenient sources all over the nation.

Get more information about HELIARC Welding and LINDE's other modern welding methods. For a free copy of the booklet, "Modern Methods of Joining Metals," address Dept. MD7 LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

FOR THE BEST IN ELECTRIC WELDING—LOOK TO LINDE!

Shells of the Earth Satellite, Project Vanguard, are made of .050-in. magnesium alloy sheet, containing small amounts of aluminum and zinc. The two hemispheres are manually welded together (above), with a cover ring, by HELIARC Welding, a LINDE development utilizing an argon-shielded tungsten arc. Brooks & Perkins, Inc., are the fabricators.

Linde TRADE-MARK

UNION CARBIDE

The terms "Linde," "Heliarc" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

REPRINTS AVAILABLE FROM MACHINE DESIGN

Multiple-Circuit Switches

lever – rotary – push or pull

A design manual on the factors to be considered in the selection and application of multiple-circuit switches.

Part One—discusses physical and electrical characteristics of lever-operated switches

Part Two—discusses physical and electrical characteristics of rotary switches

Part Three—discusses physical and electrical characteristics of push or pull switches

Part Four—discusses factors to be considered when selecting switches from these types for a specific application

---

How to select and apply

Electrical Connectors

Separable electrical connectors can often help satisfy several design objectives—convenience, portability or mobility, flexibility. Connectors provide these features in two kinds of circuits—power and signal.

Part One—discusses how to select and apply Electrical Connectors for power circuits

Part Two—discusses how to select and apply Electrical Connectors for signal circuits

Order your copies today

(Add 3% to orders for delivery in Ohio to cover state sales tax)

MACHINE DESIGN
READER SERVICE
Penton Building
Cleveland 13, Ohio

SEND ME____ copies of "MULTIPLE CIRCUIT SWITCHES" at $1.00 per copy

____ copies of "ELECTRICAL CONNECTORS" at $1.00 per copy

NAME _____

TITLE _____

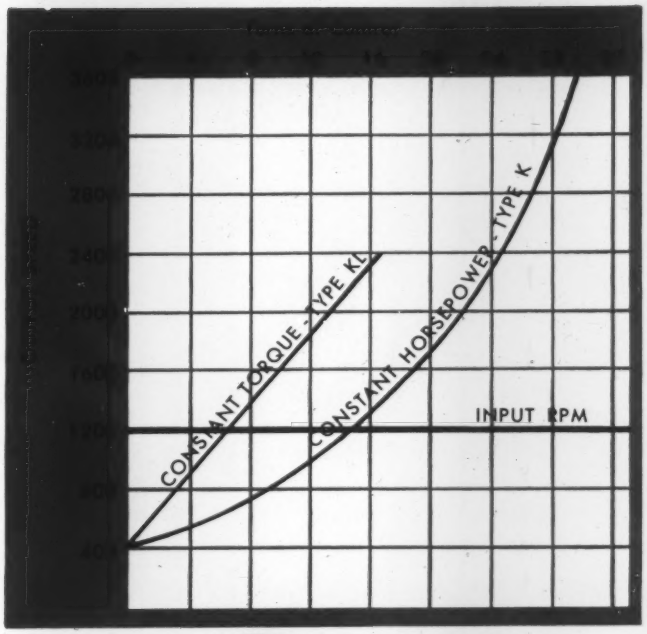
COMPANY _____

ADDRESS _____

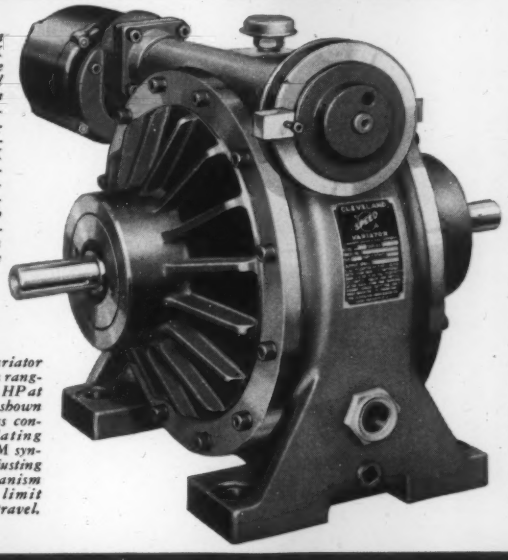
CITY _____ ZONE ____ STATE _____

☐ Remittance enclosed

☐ Please bill me



Typical speed regulation curves for the Types K and KL Variators. Type KL offers a linear speed regulating pattern, often an advantage in automatic control applications. Output speed regulation of the Type K Variator follows a geometric progression pattern. Starting at the minimum output speed, each turn of the speed regulating wheel produces a fixed percentage increase in output shaft speed.



The Cleveland Speed Variator is available in 18 models ranging from fractional to 16 HP at 1750 input RPM. Unit shown at right, used in process control, has speed regulating worm driven by 75 RPM synchronous motor, with adjusting shaft indicating mechanism modified to actuate limit switches to prevent overtravel.

CLEVELAND SPEED VARIATOR

Accurately Provides Dependable, Infinitely Variable Speed Control

ANNOUNCED late in 1954, the new Cleveland Speed Variator met instant, enthusiastic acceptance. Engineers and designers of industrial equipment already have put thousands of units into use on such varied equipment as cigarette making machines, textile machinery, metalworking machinery, pharmaceutical equipment, transfer tables, conveyors and experimental and testing equipment of many types.

Infinitely variable, the Cleveland Speed Variator gives stepless speed over a full 9:1 range—from ⅓ to 3 times input speed. Output speed can be adjusted by either a hand wheel on the Variator or by manual or automatic remote control.

The Cleveland Speed Variator offers these major advantages:

1. An extremely compact unit with input and output shafts in line and rotating in the same direction.

2. Almost any input speed up to 1800 RPM can be used—either clockwise or counterclockwise rotation.

3. Rated for constant horsepower output over a 9:1 or 6:1 range; or for constant output torque over a 6:1 range.

4. Speeds infinitely variable over entire range of adjustment.

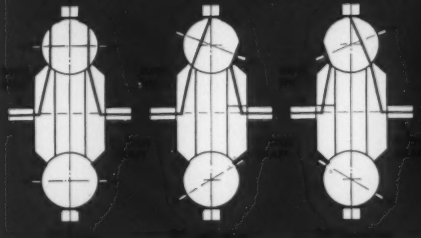
5. No slippage—positive torque response mechanism adjusts in direct proportion to the loads encountered.

6. Long life and minimum maintenance due to absence of belts or complicated linkages.

7. Ample bearing support for overhung pulleys on both input and output shafts.

Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axles on which the balls rotate (diagram, right, shows cutaway Variator with hand regulating wheel).

"It's the Drive That's on the Ball."

THE CLEVELAND WORM AND GEAR COMPANY

Speed Variator Division, 3287 East 80th Street, Cleveland 4, Ohio

Sales Representatives in all major industrial markets • In Canada: Peacock Brothers Limited.

Circle 402 on page 19

Industry's Preferred Motor Control

On all Standard Enclosures

A nationwide network of Authorized Cutler-Hammer Distributors offers prompt supply of Cutler-Hammer Three-Star Motor Control in all generally used sizes, constructions and enclosures. Also all needed control accessories and matching safety switches.

On Special Construction

Machinery builders have been quick to recognize the many advantages offered by Cutler-Hammer Three-Star Motor Control components, including the spectacular new heavy-duty oil-tight pushbuttons.

On the Finest Control Center

The new Cutler-Hammer Three-Star Unitrol provides for the quickest installation or rearrangement of the finest in motor control equipment, cost-saving Cutler-Hammer Three-Star Motor Control.

All motor control is built to high standards; functional importance requires it. But the comparison of several makes in *actual use* proves there can be wide differences!

One make of control, for example, is much easier to install, so *much* faster that the man-hours saved in installing it often more than pay the entire cost of this control . . . Cutler-Hammer Three-Star Motor Control! Comparison in use also proves this control works better, makes electric motors work harder, avoids costly work interruptions. Cutler-Hammer Three-Star Motor Control in industry's "killer" jobs has shown a trouble-free operating life *several times* that of whatever control equipment it replaced.

Discover why this is industry's preferred motor control. Compare it in *use* and see why you should also specify it as your standard. , , , CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

The Panel Builder's Handbook, a comprehensive data book on Cutler-Hammer Three-Star Motor Control components and accessories is offered free of charge to machine design and control panel engineers. Write today on your company letterhead for Pub. EE-120.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Circle 403 on page 19